Barriers and promotors of green energy adoption within a South African manufacturing company

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ABSTRACT

This study examined the factors promoting and prohibiting green energy technology adoption. The research aimed to understand why the rate of green energy adoption is low in the South African manufacturing industry, as the industry contributes significant carbon dioxide emissions, causing global warming. Literature had established that government policies and the markets were the promoters of green energy adoption, whereas supplier experience and competencies were barriers. Research questions were developed from the literature study to guide the research questions used to collect data. Case study research was conducted to build on the body of knowledge regarding the green energy diffusion and adoption phenomena. Ten knowledgeable and experienced participants were interviewed to collect data. The interviews were recorded and transcribed to prepare for data analysis. After analysing data on Atlas Ti, themes from the codes were analysed under each research question. The study supports the findings concerning promoters of green energy, adding that investors' functions also promoted the adoption; other supplier capabilities, such as the unavailability of solar storage technologies, were barriers. Hybrid models for various green energy applications and effective technologies should be developed, providing flexibility to the industries and promoting the rate of adopting green energy.

Keywords: green energy; carbon-dioxide emissions; technology; manufacturing; solar energy; innovation; adoption

DECLARATION

I declare that this research project is my own work. It is submitted in partial fulfilment of the requirements for the degree of Master of Business Administration at the Gordon Institute of Business Science (GIBS), University of Pretoria. It has not been submitted before for any degree or examination in any other University. I further declare that I have obtained the necessary authorisation and consent to carry out this research.

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ABBREVIATIONS

AFC	Africa Finance Corporation
CM	Carbon management
EU	European Union
GE	Green Energy
IFC	International Finance Corporation
IPP	Independent power producers
RE	Renewable energy
RQ	Research Question
TI	Technological innovations
UN	United nations

CHAPTER 1: INTRODUCTION TO THE RESEARCH PROBLEM

1.1 Background

The United nations (UN) hosted a global warming summit in 2019 where several countries established targets to reduce carbon dioxide emissions to net zero by 2025 to combat potential disasters of climate change (Qin, Sˇkare, Wang, & Xu, 2022). Countries have committed to adopting green energy (GE) technologies to diverge from energy produced by fossil fuels as a primary source of carbon dioxide emissions to achieve the set targets. Innovation of GE technologies is among the top agenda concerning innovative ideas globally, following other technological innovations (TI) developed through Industry 4.0. Some developing countries, such as China and India, are progressing well in implementing technologies to reduce carbon dioxide footprint through Industry 4.0 innovations, although countries, such as South Africa and other African countries, are still lagging on these developments (Coeztee, Maisiri, & van Dyk, 2021). It is also well-known that developed and developing countries are considering renewable energy (RE) technologies as the proven sustainable solutions to mitigate global warming (Dwivedi, Kapoor, & Williams, 2014).

Global warming, caused by air pollution through the release of greenhouse gases into the atmosphere, has become a major threat to public health and humanity (Adebayo, et al., 2021). The UN considered the African continent as holding maximum vulnerability to the consequences of climate change owing to the growing population and human activities (Aliyu, Modu, & Tan, 2018).

The greenhouse gases are estimated at 450ppm, translating to an increase of 2 ºC in mean ground temperatures globally (Bischof-Niemz, Calitz, Mushwana, van Heerden, & Wright, 2019). The climate change framework drafted by the UN should hold the world's temperature increase to less than 2ºC over 21 centuries (Li & Taeihagh, 2020). Countries embarked on an ongoing decarbonisation process by adopting GE technologies to respond to the adverse effects of global warming. The process involves the transition from carbon-intensive coal-based electricity generation process to GE technologies and practices (Bischof-Niemz, Calitz, Mushwana, van Heerden, & Wright, 2019) and (Graham, Mazzara, Richter, Sarrica,

& Thomas, 2018).

GE focuses on the environmental, social, and economic sustainability aspects of energy generation and consumption (Densing, Kober, Panos, & Schiffer, 2020). The GE innovations are widely diffused and adopted by firms owing to their environmental friendliness and social benefits (Stucki & Woerter, 2016).

South Africa significantly contributes to global warming as it generates 1% of carbon dioxide emissions when measured on a global scale. This is owing to the country's heavy reliance on electricity generated from coal, which releases greenhouse gases into the atmosphere (Stucki & Woerter, 2016). Coal is a common source of energy globally, and it is used in the generation of electricity.

The South African Government, similar to other governments globally with high carbon dioxide emissions, is attempting to reduce the carbon dioxide footprint in the atmosphere following the UN's target to mitigate influences of climate change. The environmental benefits of GE practices have encouraged governments to develop and implement policies to reduce the carbon footprint in the atmosphere (Stucki & Woerter, 2016). This calls for companies to review how they contribute to potential global disasters and the need to adopt GE practices to mitigate the global warming discourse.

This study aimed to assess if South Africa is progressing with achieving its commitments towards eliminating carbon dioxide emissions and focuses on the manufacturing industry, owing to its significant contribution to carbon dioxide emissions from fossil fuels. Scholars emphasise that to mitigate the consequences of global warming; there is a need for countries to transition from energy produced from fossil fuels to the adoption of GE practices. Barry and Healy (2017) contend that a successful transition to GE requires recognition of the behaviour, strategy, and values of individual actors, policies, regulations, and infrastructure.

The key fundamental in the climate change topic is that organisations need to adopt GE practices, as they proved to solve climate change. The adoption process is defined as the organisation's decision to demonstrate evidence-based intervention and commit to solving a set problem (Lundblad, 2003). Manufacturing companies are

encouraged to review their processes, especially those contributing to carbon dioxide emissions, to comply with environmental policies established to achieve zero carbon dioxide emissions (Stucki & Woerter, 2016). Stucki & Woerter (2016) contend that the benefits of GE practices will unfold if the technologies are widely diffused and adopted within organisations. There are further assertions that the success in the energy transition from fossil fuels to GE depends on the firm's willingness and ability to adopt GE innovations (Horbacha & Rammer, 2018).

1.2 Research problem

Moving from consuming energy from fossil fuel sources to GE is a key objective for most countries globally (Horbacha & Rammer, 2018). There is a clear consensus among scholars and debates that a shift from using conventional sources of energy to the adoption of GE will be an effective way to respond to climate change (Qin, Sˇkare, Wang, & Xu, 2022).

South Africa is one of the top three countries within the African continent to make up half of the total energy consumers (Aliyu, Modu, & Tan, 2018), with 80% of corporate entities using energy produced from fossil fuel sources (Ganda & Milondzo, 2018), South Africa needs to take its obligation to reduce carbon dioxide emissions seriously, by accelerating the adoption of GE practices. Acceptance of GE technologies is low globally (Ahmad, Jabeen, & Zhang, 2021) and (Tobias, 2019), and therefore, it is important to understand the drivers of GE adoption from a South African context.

Diffusion of innovation theory suggests that generating innovative ideas will be followed by diffusion into the market, where processes and technology innovations will be widely known and adopted by consumers (Grafström & Lindman, 2017). The intended result of the innovation and its diffusion is a successful adoption; however, the diffusion process may be unsuccessful owing to several factors (Grafström & Lindman, 2017). GE innovation adoption models have not been developed owing to the limited knowledge of the drivers of adoption (Tobias, 2019). This lack of in-depth understanding created a divergence and required further investigation to build on the existing knowledge of the diffusion of innovation phenomena.

Most countries have introduced policies and incentives to motivate organisations to adopt green energy practices; however, the diffusion of GE innovations remains low (Dwivedi, Kapoor, & Williams, 2014). This leaves a divergence in the body of knowledge around drivers of GE diffusion and adoption. Qin, Yong, S'kare, Marinko, Wang & Xu (2022) pointed out that GE technologies have been a subject of studies over the past two decades; however, the public uptake of the technologies is low. Noseleit (2018) suggests that the diffusion of GE technologies from the original innovation country may lag owing to spatial challenges. The country borders and transmission of such technologies may hamper GE technology adoption.

The debates on the transition from the generation of electricity using fossil fuels to the adoption of GE practices have focused mainly on the technical aspects of the transition and inadequately on the social influences and the socioeconomic costs of decommissioning the coal systems (Bischof-Niemz, Calitz, Mushwana, van Heerden, & Wright, 2019). According to Barry and Healy (2017) and Geels (2019), the transition should be objective and consider the function of infrastructure, labour, policies, regulations, and markets.

Technology innovation and adoption are on the rise within manufacturing companies around the world, particularly in developed countries; however, the diffusion of innovation phenomenon in the South African manufacturing context has not yet been studied (Coeztee, Maisiri, & van Dyk, 2021).

1.3 Research purpose

The rate at which South African companies adopt GE innovations demonstrates it is not enough not only to understand the global warming concern from a technical and technological perspective, but also to consider factors leading to acceptance or rejection of this good practice. The diffusion of innovation theory best describes the organisation's intent and ability to discontinue the usage of conventional energy methods for the adoption of GE innovations. A case study research design was selected to explore the practical and theoretical implications of the GE adoption phenomena using a South African manufacturing company.

The research aimed to understand organisational characteristics leading to the

adoption of GE technologies. Factors that may function as promoters or barriers to the diffusion and adoption of GE innovations were explored during the study. Scholars undertook debates around the GE technologies available, barriers relating to implementation and the costs of GE technologies focusing little on the barriers and promotors of GE adoption in manufacturing companies.

Stucki and Woerter (2016) emphasise that previous investigations focused on inter-firm diffusion of GE, discussing the diffusion of GE among various firms. It is equally crucial to study the diffusion of GE within a single firm to understand the patterns and characteristics of innovation leading to the intra-firm adoption of GE (Stucki & Woerter, 2016). The divergence informed the case study choice of research in the literature on the intra-firm diffusion of GE.

Acceptance of GE is one of the key factors facilitating the diffusion of GE innovations (Ahmad, Jabeen, & Zhang, 2021). The study provided more insights into how the firm's acceptance of GE technologies led to success in adopting the practices. The diffusion of innovation theory is relevant in demonstrating how energy generation technologies have diffused from using traditional energy sources to GE to mitigate the potential global warming crisis.

Providing the global warming threats and their consequences to human lives, the research focused on the rate of GE adoption by a South African manufacturing company owing to the industry's significant contribution of carbon dioxide emissions to the atmosphere. The research explored the barriers and promotors of GE adoption using the diffusion of innovation theory as the main theoretical anchor. The study explored why the rate of GE adoption has not improved despite global warning awareness and provided insights into the factors that promote adopting GE innovations and perceived risks that led to slow adoption.

1.4 Research setting

Of the 80% of electricity end users in South Africa, the manufacturing sector accounts for 37,7% (Ganda & Milondzo, 2018). The interest in studying the GE adoption within the manufacturing sector is attributable to the significant influence that the industry has on global warming.

Manufacturing companies in developed countries adopted Industry 4.0 (14.0) to enhance their industry's competitiveness and growth. Coetzee, Maisiri, and Van Dyk (2021) emphasised that no studies were conducted to focus on the technology innovation adoption in South African manufacturing companies. They undertook research to identify factors that inhibit the sustainable adoption of Industry 4.0 within the country's manufacturing sector.

The study probed the observations of managers and specialists within the industry. The findings emphasise that structural inequalities, cultural constructs, and youth unemployment, were crucial inhibitors to the adoption of Industry 4.0 (Coeztee, Maisiri, & van Dyk, 2021). The context of the study was mainly on adopting technology innovation by multiple firms.

The interest in studying GE technology adoption was triggered by a lack of literature specifically around drivers of technology adoption, as emphasised by literature studies (Grafström & Lindman, 2017). This research focused on barriers and promotors of GE adoption within a single firm context. Grasfström and Lindman (2017) recommended a qualitative case study research to explore the GE diffusion phenomena further. The study aimed to collect insights on what motivated the manufacturing company to adopt GE practices and which barriers prohibited the complete adoption of such practices.

1.5 Contributions to proposed research

1.5.1 Practical contributions

The scholarly discussions focused on GE innovations and their advantages in mitigating environmental degradation as an alternative to the traditional coal-based energy generation and the influence of climate change; however, they did not present convincing arguments about the reasons for the low adoption of GE innovations, particularly in the manufacturing industry.

The research provided insights into the facilitators of GE diffusion and identified key factors for consideration when adopting the practices. The findings could help in the development of adoption models for firms with similar operating settings and complexity. Organisations can build strategies and increase the uptake of GE

innovations by learning from the study findings. The research outcome provides a better understanding of why some manufacturing companies lagged in adopting GE practices; therefore, it provides opportunities for other companies to develop a risk mitigation plan for potential shortfalls that may arise from adopting GE technologies.

Uncertainties associated with GE practices are perceived to influence the adoption, whereas risk aversion is a common factor among most organisations (Ahmad, Jabeen, & Zhang, 2021). Ahmad, Jabeen, and Zhang (2021) make an example of how consumers refused to adopt nuclear energy despite a clear awareness of its benefits. This was owing to the safety risks that the technology could present. The study informs about some successes of GE adoption and implementation in manufacturing sites.

1.5.2 Theoretical contributions

After conducting a quantitative study to understand the dynamics between the interconnected phases from innovation to diffusion, Grasfström and Lindman (2017) established that the policies implemented by governments to encourage the adoption of GE innovation may affect various phases contrarily in the diffusion of the innovation process. Grasfström and Lindman (2017) recommend a further qualitative case study analysis in the GE field to enrich theoretical knowledge on the promoters and barriers to innovation adoption.

The main divergence in the diffusion of innovation theory is around drivers of adoption, leading to slow diffusion of innovations (Grafström & Lindman, 2017). Tobias (2019) contends that the drivers of GE adoption are institutional, market, organisational and behavioural; however, these divers may not be generalised for all industries. This study focused on the GE adoption phenomena and built on debates around the diffusion of innovation theory.

The research focused on building the applicability of the diffusion of innovation theory and expanded more on the practical successes and limitations of the theory. The debates in the scholarly research have not only emphasised the barriers and promoters of GE adoption in the manufacturing sector, and the study offers insights that contribute to the body of knowledge on the GE phenomena within a

manufacturing firm's context.

1.6 Definitions of key concepts

The diffusion of innovation theory entails spreading innovative ideas across the organisation and presenting new ideas to organisations. The diffusion of innovation concept focusses on the layout of the ideas, which in this case means the GE technologies and processes of rolling out the innovation to the consumers (Grafström & Lindman, 2017). The adoption concept approaches the acceptance part of the technology, which became the centre of this research (Dwivedi, Kapoor, & Williams, 2014).

GE is defined as energy generated from sources that do not release carbon dioxide emissions to the atmosphere or energy produced from renewable sources (Qin, Sˇkare, Wang, & Xu, 2022). Data sources used to build arguments in this research have mostly aligned with GE technologies being key drivers to reducing the severity of climate change; however, the key concern revolves around the adoption rate of the technologies and further the drivers and inhibitors of the adoption.

Another concept that emerged in this study is the circular economy, defined as the processes of capturing waste, heat, gases and by-products and then recycling them to reduce their potential influence on the environment. The circular economy concept is also intended to achieve net zero emissions from fossil fuel sources (Davis, Lewis, Shaner, & al., 2018).

The process of recycling and removing carbon dioxide from the atmosphere is also called carbon management (CM), crucial to achieving a net zero emissions energy system (Davis, Lewis, Shaner, & al., 2018).

1.7 Outline of the document

This study outlines the business problems associated with GE adoption and a literature review. The concept of GE diffusion and innovation is described using the theoretical lens of other researchers and practical experiences from a company perspective. The research methodology section covers how data were collected throughout the study to answer research questions, as outlined in Chapter 3 of this document. The report concludes with a discussion of the results and conclusion.

CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

The world experienced significant energy demand in the past decades owing to an increase in economic activities and population. An increase in energy demand has substantially pressured the global energy market as the industry's way of meeting the demand means increasing the usage of coal as alternative energy sources are not yet at the capacity to replace traditional sources of energy (Qin, Sˇkare, Wang, & Xu, 2022).

South Africa has been reported as the largest explorer and producer of coal in the sub-Saharan region, with 87% of the country's total energy obtained from coal. The country is ranked 5th concerning global energy consumption, and it constitutes 1% of global carbon dioxide emissions.

Coal is the second largest energy source globally, accounting for 30% of the total energy produced. Over 40% of energy from coal is used to generate electricity (Adebayo, et al., 2021). The rise in electricity consumption because of growth in population and economic activities requires more coal usage, creating considerable pollutants as carbon dioxide emissions.

The influence of carbon dioxide pollutants on the environment poses a serious global warming threat. This implies that the producers and users of energy that emit carbon dioxide pollutants should save the planet (Adebayo, et al., 2021). Unlike in the past, the outlook predicts that RE sources will contribute the most to meeting global energy demand rather than conventional energy sources as countries are expected to comply with environmental regulations (Adebayo, et al., 2021).

As the world's economy continues to grow, it is expected that global electricity consumption will more than double over the next 40 years (Densing, Kober, Panos, & Schiffer, 2020). This considerable increase in global energy consumption requires countries to evaluate their capacities in energy generation to meet the demand. Global energy generation in the past 40 years was predominantly covered by fossil fuels, oil and gas. There has been a slight integration of RE since 1987 to date; however, the rate at which conventional energy sources polluted the environment is

now at a stage where it threatens human lives (Densing, Kober, Panos, & Schiffer, 2020). Scholar debates have reached a consensus that GE technologies are key substitutes to traditional energy sources, such as coal, and that countries should reduce emissions of greenhouse gases to prevent potentially catastrophic consequences of global warming (Qin, Sˇkare, Wang, & Xu, 2022).

Scholars define GE as an energy generated from renewable sources and technologies, such as solar, biomass, and wind farms (Qin, Sˇkare, Wang, & Xu, 2022). The scholars believe that the innovations and consumption of GE can be scaled up to the industrial level and will assist countries in achieving net zero carbon pollution (Qin, Sˇkare, Wang, & Xu, 2022). Contrary to the GE definition, TI is defined as non-renewable technologies that convert carbon dioxide pollutants into by-products that can be recycled and repurposed (Su, Pang, Tao, Shao, & Umar, 2022). Both technologies, such as RE and TI, are effective in reducing carbon dioxide emissions; however, the most effective method has not yet been proven (Su, Pang, Tao, Shao, & Umar, 2022).

GE technologies have the potential to rejuvenate the economy by supplying affordable, cleaner electricity and climate change solutions, and for this reason, most economies will adopt the technologies (Ahmad, Jabeen, & Zhang, 2021). The transition from traditional energy sources to GE practices; however, it goes with critiques from the public owing to issues such as user unfriendliness, a lack of knowledge on environmental matters, and lack of government policy construct (Ahmad, Jabeen, & Zhang, 2021).

Ahmad, Jabeen, and Zhang (2021) contend that understanding consumer behaviour on acceptance of GE may propagate adoption. The uncertainties around GE technologies affect public acceptance; therefore, a study was conducted to evaluate public behaviour as a crucial factor for the uptake of the technologies. Ahmad, Jabeen, and Zhang (2021) further contend that although GE practices in developing countries rely heavily on foreign investment in deploying the technologies, the developing countries can develop the technology domestically and adds that infrastructure developments may motivate consumers if they believe in the value of GE practices. The consumer perception of GE technologies, whether in a household

setting or industrial application, plays a key role in adopting GE technologies.

The theory to best describe the GE adoption phenomena is the diffusion of innovation theory, which outlines how innovative ideas and processes spread across organisations (Dwivedi, Kapoor, & Williams, 2014). The theory is used in this study to explore how a South African manufacturing company adopts GE technologies and other TI to replace or reduce the overreliance on energy produced from coal. This transition process is a good example of diffusion of innovation, where newer technologies will replace the conventional method of energy generation through acceptance and adoption by consumers.

Lundblad (2003) contends that a lack of innovation diffusion across organisations gives rise to common development and performance improvement constraints. He further adds that there is a divergence between idea development and the actual adoption of innovation across organisations. Idea development focuses on the technology and technical aspects of innovation and often excludes factors that play a key role in the implementation success of innovation. These assertions are supported by findings made by Dwivedi and Kapoor (2014) that GE solutions are popular among end users; however, the rate at which consumers adopt GE practices is low, both from an individual and organisational levels.

GE technologies received significant attention globally attributable to their potential positive influence in fighting global warming (Qin, S˘kare, Wang, & Xu, 2022). Social acceptance has been identified as one factor slowing down the adoption of GE technologies. Qin, S'kare, Wang & Xu (2022) emphasise that social acceptance of GE will remain a challenge soon owing to challenges and difficulties from various aspects of GE practices.

2.2 Theoretical anchor

The diffusion of innovation theory best describes the GE adoption phenomena, and the research aimed to discuss divergences in the theory and contribute to the knowledge around GE innovation, diffusion, and adoption. Grasfström and Lindman (2017) define innovation as the commercialisation of newly created ideas by advertising goods and services or marketing new manufacturing processes and

methods. The study further claimed that innovations are not made up of new inventions but could comprise newly packaged old technologies or processes. The key assumption of the theory is that innovations are often driven by pursuing effective ways of doing things in the quest to save cost, the environment or human lives and that after the innovation of ideas, diffusion of new technologies, ideas or optimised processes in the market (Grafström & Lindman, 2017).

Innovation in GE technologies attempts to approach environmental pollution challenges that have become a tropical topic globally. Scholars and authorities have all aligned with the idea that new and effective ways of generating energy without releasing greenhouse gases into the atmosphere are of paramount importance for environmental sustainability (Horbacha & Rammer, 2018). The common innovations for the generation of GE include RE technologies, such as solar, wind, hydropower and biomass (Su, Pang, Tao, Shao, & Umar, 2022).

The energy transition from fossil fuels becomes diverse, as the diffusion and adoption of GE innovation is uneven. The innovation of RE technologies has become a key determinant of GE adoption (Noseleit, 2018). Noseleit (2018) contends that advancing GE technologies play a critical role in the adoption of RE technologies, although the study did not quantify this influence. The study further contended that the proximity of innovation is inclined to drive adoption; however, it remains unknown how the transition to GE technologies is influenced by innovation activities (Noseleit, 2018).

The diffusion process occurs when the ideas or technologies become progressively known and are available to consumers; however, the diffusion process may yield expected or unexpected results (Grafström & Lindman, 2017). In the GE diffusion context, several studies confirmed that the innovation of technologies has well widened, although the diffusion has not progressed at the expected rate (Dwivedi, Kapoor, & Williams, 2014). While increasing energy production from environmentally friendly sources is a goal for several countries, the successful diffusion of such environmentally friendly solutions is yet to be proven (Grafström & Lindman, 2017). Technology adoption is a key measure of diffusion success.

The diffusion of innovation theory suggests that after the innovation of ideas,

marketing and processes will lead to diffusion of the technologies or processes (Dwivedi, Kapoor, & Williams, 2014). Although the phenomena can be demonstrated in the GE adoption context, there is a divergence in understanding why well-known and available environmental pollution solutions have not been diffused and adopted by organisations at a higher rate (Stucki, 2019).

2.3 Innovation, diffusion, and adoption of green energy (GE) technologies

The literature review on technology innovations, diffusion, and adoption has been outlined to emphasise debates on the GE topic. The literature review supports the theory and builds up on the theory context. The literature focuses on three key areas of theory: innovation, diffusion, and adoption of GE technologies.

2.3.1 Renewable energy innovations

The innovations of RE technologies are perceived as critical for driving GE adoption (Noseleit, 2018). It is also known that countries are not innovating the technologies because they are distant from such innovations or it may be time-consuming to adopt the technologies (Noseleit, 2018).

Solar energy is one of the most familiar and attractive methods to combat global warming issues owing to its direct availability. Although the technology is not necessarily new, the suppliers have developed various distribution processes and mechanisms to increase consumer production and availability (Dwivedi, Kapoor, & Williams, 2014).

The solar energy scenario demonstrates what is meant by innovation and how technology has widened. Research findings by Kapoor and& Dwivedy (2014) have proven that the diffusion and adoption of solar energy innovations by organisations are low, which means the diffusion rate is also low.

2.3.2 Current issues with renewable energy technologies

It is estimated that energy produced from renewable technology sources sits at 27% of global energy production, whereas, in Africa, only 9% of the total energy produced

in 2020 was from RE sources (Abbas, Iqbal, Koura, Su, & Zhang, 2022). Of the various GE technologies available, it is not yet known which of those technologies, such as renewable sources and recycling methods, are more effective in achieving reduced carbon dioxide emissions in the atmosphere (Su, Pang, Tao, Shao, & Umar, 2022).

The government calls for existing production infrastructures to deploy TI aimed at improving energy efficiencies by reducing carbon emissions; however, there is no evidence to conclude which method between other TI and RE innovations is more effective in combating carbon dioxide emissions (Su, Pang, Tao, Shao, & Umar, 2022).

Dwivedy and Kapoor (2014) and Allen (2017) identified characteristics of innovation affecting diffusion and adoption across organisations, but failed to identify a specific attribute of innovation and diffusion affecting the rate of GE adoption in the manufacturing industry. Boucert (2020) also contends that the factors driving the adoption of GE are not yet clear from the literature and therefore, he recommends that further studies be conducted to explore the determinants of GE adoption.

2.3.3 Net zero carbon dioxide technology innovations

According to Su, Pang, Tao, Shao, and Umar (2022), there is no defined single way to achieve net zero carbon dioxide emissions, and the RE sources are not enough as the only solution to facilitate the carbon dioxide abatement agenda. Su, Pang, Tao, Shao, and Umar (2022) further suggest that promoting more TI will create platforms to curb carbon dioxide emissions.

GE technologies will certainly reduce carbon dioxide emissions, but in contrast, the carbon-dioxide emissions are generated during the production and construction of such GE technologies (Su, Pang, Tao, Shao, & Umar, 2022). The energy supplied by renewable technologies has its limitations as it often does not meet the demand quantities, especially in operations that run continuously without stopping (Su, Pang, Tao, Shao, & Umar, 2022). The study by Su, Pang, Tao, Shao, and Umar (2022) reported that innovations to mitigate the lack of continuous energy supply include storage; however, the storage technologies are expensive.

Although RE technologies are popularly known as the most effective ways to reduce carbon dioxide emissions, there are other ways to achieve net zero carbon dioxide emissions, such recycling technologies to capture the pollutants generated from fossil fuels and converting them into by-products that can be repurposed (Davis, Lewis, Shaner, & al., 2018). This approach is called a net zero emissions energy system, indicating an energy system that does not emit carbon dioxide (CO_2) into the atmosphere.

A net zero energy management system aimed at providing de-carbonising processes was explored and established to be costly to achieve owing to the under-development and lack of demonstration for such technologies (Davis, Lewis, Shaner, & al., 2018). A substantial increase in the cost of some known technologies is one barrier prohibiting the achievement of a net zero emission target. Some contend that the innovation and diffusion of net zero-emission technologies could reduce the cost of technology and introduce a variety of options soon (Davis, Lewis, Shaner, & al., 2018). Efforts, such as coordinating activities across the manufacturing industries, could help with reducing costs by fully using capital-intensive resources (Davis, Lewis, Shaner, & al., 2018).

The transition to a net zero emissions energy system depends on various factors, such as the balance between demand and energy supply, recycling and removal of carbon dioxide (CO_2) from the atmosphere, alternative manufacturing processes, cost of technology, institutional and organisational barriers and electrified substitutes (Davis, Lewis, Shaner, & al., 2018).

2.3.4 The circular economic innovations

According to Davis, Lewis, Shaner, and al et (2018), some industrial processes are laborious to operate without energy that generates CO_2, and this challenge has brought about the concept of the circular economy. In a quest for transition to a sustainable economy, the World Economic Forum and other corporations and governments globally endorsed the concept of the circular economy, which approaches regenerative systems and ensures that waste, energy leaks and emissions are recycled to reduce environmental influence (Corvellec, Johansson, & Stowell, 2022).

Although the concept of the circular economy is geared towards long-term economic suitability and ensuring that any potential activities that may cause adverse influence on the atmosphere are reduced, the study by Corvellec, Johansson, and Stowell (2022) contends that the infrastructure for such systems is underdeveloped. The study further adds that business models for a circular economy are questioned on their practicality for implementation and that the ideas are mostly scattered across various academic fields.

Davis, Lewis, Shaner, & al., (2018) suggest that the technology innovations to achieve net zero CO_2 emissions, such as those of the circular economy concept, may take decades to research, develop, and deploy. The circular economic concept appreciates that the existing infrastructure that drives the economy in Africa and other developing countries is mostly still using conventional energy generation technologies. Provided that a complete transition to renewable sources may take decades to implement, companies that use fossil fuel sources to generate energy and end users who depend on such old technologies to run their operations need to make do with what they must retain employment and continue feeding most poor people in the African continent. The concept of the circular economy will, therefore, play a vital role in ensuring that the environment is protected while the operation of firms with old unfractured assumptions continues.

2.3.5 Green energy diffusion

Diffusion of RE technologies has been described as an effective tool to minimise the carbon dioxide (CO_2) emissions (Abbas, Iqbal, Koura, Su, & Zhang, 2022). The GE diffusion determinants influence how people change their preferences as the cost of RE technologies reduces. The slow adoption of GE technologies significantly influences the diffusion process (Abbas, Iqbal, Koura, Su, & Zhang, 2022). The facilitation of GE diffusion highly depends on the rate at which the technologies are adopted.

Although there is unambiguous evidence that carbon emissions significantly influence global warming and that GE technologies exist to remedy the consequences, there is a lack of innovation diffusion across organisations. The government, as the main facilitator of the GE diffusion process, should create more

awareness among citizens while controlling and managing advertising to balance GE diffusion and adoption (Abbas, Iqbal, Koura, Su, & Zhang, 2022).

According to Hascic, Medhi, and Popp (2011), RE technologies comprise a small portion of the world's energy portfolio and are more expensive to use than traditional fossil fuels (Hascic, Medhi, & Popp, 2011). In 2011, RE sources contributed 18% of the world's power generation, whereas hydropower was reported to be the most commonly used RE source (Hascic, Medhi, & Popp, 2011). Solar energy, biomass and other renewable sources comprised only 2,1% of the total energy generation in 2011. Since then, GE innovations have advanced, and other technologies, such as solar energy systems, have emerged and gained popularity. It was remarked around the same time that although GE technologies were expensive, the costs for such technologies were gradually declining (Hascic, Medhi, & Popp, 2011).

In 2021, Ahmad, Jabeen, and Zhang (2021) confirmed that GE technologies have the potential to rejuvenate the economy by supplying affordable and cleaner electricity. The cost of GE technologies is considered one of the major determinants of GE technology diffusion (Ahmad, Jabeen, & Zhang, 2021).

Hascic, Medhi, and Popp (2011) contend that much of the lowered cost of RE technologies was driven by government policies through government-sponsored research or through enacting the policing to promote GE technologies (Hascic, Medhi, & Popp, 2011). The government is, therefore, a facilitator of GE diffusion.

Government policies are crucial instruments to drive and stimulate the diffusion of GE practices among organisations and to force companies to reduce carbon dioxide emissions (Stucki & Woerter, 2016). The influence of various policy types is unknown, since various energy policies cause various reactions from companies and lead to the adoption of various GE technologies (Stucki & Woerter, 2016).

Although public and environmental air pollution policies are some of the concrete tools to curb using coal in energy production, Li and Taeihagh (2020) contend that governments should develop a policy mix for both coal-based and green energy production to drive the diffusion of GE while allowing a smooth transition from fossil fuels. A gradual transition is promoted through adopting other TI, such as the energy

management systems best described by the circular economy concept.

The study further adds that dramatically adopting GE technologies may have unintended consequences (Li & Taeihagh, 2020). An example has been made in China, where the country adopted hydroelectric technologies and progressed in employing the technology as an alternative to coal-generated electricity. The technology accounts for 16% of global energy production; however, it has adverse influences on the downstream river ecosystems, while the processes are easy to operate and maintain (Li & Taeihagh, 2020). International dynamics, such as the markets and investors, are driving the diffusion of green energy technologies; however, such dynamics need domestic policies for the facilitation of GE technology diffusion (Matsuo, Steinemann, Schmidt, & Steffen, 2018).

2.3.6 Green energy adoption

Findings from the study by Qin, Yong, S'kare, Marinko, Wang, and Xu (2022) established that early adopters of GE technologies were driven by environmental concerns; however, with an emphasis that attitudes are the best characteristics of GE adopters. Solar energy technologies have high installation costs, although maintenance costs are low and economically feasible, owing to long-term benefits (Dwivedi, Kapoor, & Williams, 2014).

The perceived excessive costs of solar energy and other GE innovations may explain the low adoption rate among green energy technologies in South Africa. The research by Bischof-Niemz, Calitz, Mushwana, van Heerden and Wright (2019) revealed that it is cheaper for new investments in South Africa to be solar PV and wind technologies compared to the traditional coal-based electricity systems; South Africa has a golden opportunity to transition from fossil fuels and to achieve up to 75% GE share by 2050. This means that the large coal fleet in the country will require decommissioning while investments are made in the new GE generation capacity (Bischof-Niemz, Calitz, Mushwana, van Heerden, & Wright, 2019). This research finding demonstrates that technological advancement could facilitate the diffusion and adoption of GE technologies; however, the study did not evaluate why the rate of GE adoption is low.

Qin, Yong, S'kare, Marinko, Wang, and Xu (2022) further add that RE policies facilitated the innovation and diffusion of GE technologies; however, the implementation or adoption of the technologies depends on such policies. Some developing countries in the European Union (EU) adopted the Kyoto protocol by signing the binding emissions limit on greenhouse gases, which includes specific targets for GE adoption (20% of EU energy needs), production quotas, and tax credits (Qin, Sˇkare, Wang, & Xu, 2022).

Bourcet (2020) supports the narrative that human activities and their influence on climate change are well articulated and understood by the international community, including that GE solutions will mitigate the adverse effects of global warming; however, the electricity produced from fossil fuels has continued to dominate the energy sector, whereas green energy consumption increases slowly. The slow rate of adoption has become the primary interest and focus area for the study.

Stucki and Woerter (2016) add that one of the important reasons for the slow adoption of GE practices is owing to its benefits being mostly public rather than private. They further explain that GE technologies are slow at diffusion because companies are not willing to pay for technologies that have no direct benefit to them. Stucki and Woerter (2016) identified three categories of policy that may influence the diffusion of GE technologies, indicating regulations, green taxes, and subsidies. They established that energy taxes and subsides were tested instruments that proved to be the most effective non-political policy instruments to drive GE technology diffusion. Regulations were a command-and-control instrument with little influence on the GE adoption rate.

The innovation of RE technologies has become a key determinant of GE adoption (Noseleit, 2018). The study further contends that the proximity of innovation is inclined to drive adoption; however, it remains unknown how the transition to GE technologies is influenced by innovation activities (Noseleit, 2018).The risk aspects as an identified characteristic of GE adoption must be separated to the level where each can be evaluated against its influence on GE adoption (Dwivedi, Kapoor, & Williams, 2014). The various facets of risks will determine the mitigation strategies to promote the diffusion and adoption of GE innovation.

Energy consumers are risk averse and would default to using traditional sources of energy instead of paying for GE technologies and dealing with uncertainties thereof (Ahmad, Jabeen, & Zhang, 2021). Studies have left divergences in understanding the implications of investment risks in GE technologies, and whether GE technologies are the best solutions as a substitute for load-shedding is not known.

Knowledge is another key characteristic of GE innovation; in using any provided technological innovation, an individual's knowledge about that innovation and the related skills required to use the innovation often determines the perception of complexity associated with that innovation for the individual (Dwivedi, Kapoor, & Williams, 2014) It is not known whether the complexity or ease of use has a significant contribution towards the slow adoption of GE practices.

2.4 Chapter conclusion

GE is energy generated from sources that do not release carbon dioxide emissions into the atmosphere or energy produced from renewable sources (Qin, Sˇkare, Wang, & Xu, 2022). Su, Pang, Tao, Shao, and Umar (2022) contend that renewable technologies are not the only solution to mitigate global warming effects. The emphasis on implementing other TI, focusing on recovering emissions and recycling methods regarding the challenges encountered by organisations whose designs and infrastructure are too old to retrofit renewable technologies, was made. The RE sources are inadequate as the only solution to facilitate the carbon dioxide abatement agenda.

There is a lack of a framework and measurement method for the diffusion of GE technologies (Dwivedi, Kapoor, & Williams, 2014). A need, therefore, exists to undertake an empirical investigation of potential factors that act as promoters or barriers to the adoption and diffusion of GE innovations (Allen, et al., 2017).

CHAPTER 3: RESEARCH QUESTIONS

Research questions were developed after conducting a desk top literature review to understand debates around adopting GE technologies. The divergencies identified by various researchers are summarised to formulate the research topic and, ultimately, the questions that guided the data collection.

3.1 The main research question

The main question that the research intended to answer are:

What are the green energy adoption's promotors and barriers?

This research question could only be answered after analysis of responses from the research participants. The research further explored factors that facilitated adoption of GE practices by the organisation and those slowing down the process. Two subsequent research questions were developed to understand the GE adoption phenomena further and to aid the researcher in answering the primary research question.

3.2 The subsequent research question(s)

The subsequent research questions answered questions around why GE innovations have not diffused at a higher rate in the manufacturing sector. It has been discovered from various studies, such as Tobias (2019) and Dwivedy and Kapoor (2014), that the solutions to reducing fossil fuels emissions are through adopting GE technologies, but the diffusion and adoption of such technologies are low.

Subsequent questions were directed to the study participants:

RQ1: What motivated the company to consider green energy technologies?

RQ2: What risks are the company exposed to, hindering the complete adoption of green energy practices?

The study aimed to understand the drivers and barriers to GE adoption through an enquiry-based case study research. Stucki (2019) contends that the drivers of GE

adoption are organisational, behavioural, market-related, and institutional. The observation of behavioural barriers was further supported by Dwivedi, Kapoor, and Williams (2014), contending that energy consumers are risk averse; this could explain why most would prefer to remain on coal-generated energy instead of adopting GE technologies. The risk-averse behaviour was investigated as a research question to collect more understanding of the perceived risks by the organisation in the study.

CHAPTER 4: RESEARCH METHODOLOGY

4.1 Introduction

The research methodology chapter outlines the process followed to collect data during the study. A case study research design was selected using an exploratory approach to draw insights from participants for the development of the body of knowledge on GE innovation, diffusion and adoption. The literature review detailed in Chapter 2 aided the researcher in identifying the relevant theory and forming the primary research question: *What are the green energy adoption's promotors and barriers?*

Data collection was conducted through face-to-face and online semi-structured interviews with employees, service providers and company executives who had knowledge and experience with GE innovations. The limitations and data quality controls are explained at the end of this chapter.

4.2 Research methodology and design

The interpretivist epistemological research approach was employed because the researcher was interested in understanding the diffusion of innovation phenomena within the GE field. The approach is used when the researcher is attempting to understand various dynamics within the organisation and a particular way where information is interpreted by the organisational team members (Saunders & Lewis, 2018). The rationale behind the choice was to allow the researcher to collect insights into various actors, enabling or disabling GE practice adoption.

The qualitative research method was a means to connect with participants and unwrap their practical experiences about the GE phenomena. The mono-qualitative method was the choice for the study as the research attempts to answer exploratory questions such as "how?", "what?" and "why?" (Bonaiut, et al., 2016). The research approach considered the perceptions, experiences, reactions, conceptions, beliefs, and emotions and not that of a researcher. An in-depth analysis of GE diffusion, innovation and adoption phenomena was conducted using a single firm to gain a greater understanding and knowledge of the factors that facilitate GE adoption. The case study research provided an exclusive opportunity to understand the research

problem from the observation of a single organisation while giving participants the freedom to express their unique experiences and observations (Alam, 2020).

Data was collected using the cross-sectional approach, where multiple participants were interviewed at a single point in time (Saunders & Lewis, 2018). Participants were provided with flexible guidelines during the interview to expand on their responses without feeling restricted.

The GE technologies are well-known globally for their effectiveness in curbing carbon dioxide emissions; however, literature studies indicated a clear divergence of knowledge concerning factors facilitating GE adoption (Dwivedi, Kapoor, & Williams, 2014). The research focused on adopting GE practices by a South African manufacturing firm that has accepted the GE innovations and its responsibility to contribute towards achieving zero carbon emissions through adopting GE technologies. The research explored how the company has incorporated GE innovations into their energy consumption model to reduce heavy reliance on energy generated from fossil fuels.

Most studies conducted around the transition from fossil fuels to GE technologies have not presented convincing arguments about why GE adoption has not made significant progress, and this motivated the researcher to conduct qualitative analysis to understand some barriers and promoters of GE adoption as recommended by Grasfström and Lindman (2017). The drivers of innovation adoption were explored during the study to enrich the diffusion of innovation theory.

The research used an inductive reasoning approach to collect in-depth knowledge of the diffusion of GE innovation phenomena. The inductive reasoning approach was relevant to this study; the intent was to understand the barriers and promoters of GE adoption from the experiences and observations of the organisation's representatives (Bonaiut, et al., 2016).

Inductive reasoning has been described as moving from specific observation to generalisation and theory development where repeated patterns and occurrences are observed to formulate propositions or hypotheses (Saunders & Lewis, 2018). Observations in this study were made on the participant's perspectives to draw

common themes from their views. The participant's observations were informed by their individual experiences and the existing systems and processes within their organisations (Bonaiut, et al., 2016).

4.3 Population

Unlike quantitative research, which approaches copious quantities of data, qualitative studies use small samples to collect information about the difficulties, complexities, and differences within the research phenomena (Alam, 2020). The firm comprises a small population of about 27 employees with technical, management and commercial expertise. The project phase that the company is undergoing requires extensive consulting services as the organisation is working towards completing the construction of its manufacturing plant. The knowledgeable informants were allowed to authentically express their thoughts and observations about the GE innovation phenomena during the interview process.

4.4 Unit and level of analysis

While other studies around the innovation of GE technologies were conducted across various organisations, this study focused on a single firm within the South African manufacturing industry. The study aimed to obtain an in-depth analysis of the GE innovation phenomena from the company executives, employees, and service providers attributable to their knowledge and experiences in the manufacturing industry. The organisation was the study unit of analysis, whereas the level of analysis was the individuals with experience in the manufacturing industry.

4.5 Sampling method, criteria, and size

A purposive sampling method was employed for the study, where the researcher used judgement to select participants to help answer the research questions. The approach to selecting the number of respondents was based on the size of the organisation and the researcher's ability to maintain close contact and relationship with participants. This approach is essential to encourage thoughtfulness, openness, and information sharing and is critical for data quality control and validation (Alam, 2020).

A non-probability sample was selected from the population to collect a maximum variation of data for the study as the sampling frame is unavailable (Saunders & Lewis, 2018). The reason for choosing the sampling method was because data collection used experts from various subject matters and company executives and employees. The samples were existing networks within the organisation, accessed during the normal course of business. The total number of respondents was determined by the data saturation point, where the researcher stopped collecting data after no new information, themes, or codes could be achieved from the participants (Alam, 2020).

The researcher's experience in the manufacturing industry has potentially influenced the sampling, and the sample selected consists mostly of experienced individuals with extensive technical and managerial experience. A sample of up to 10 knowledge participants with various backgrounds was interviewed. These participants possess expertise, knowledge, and experience from various manufacturing companies. The participants either work for the organisation or provide outsourced services to the company.

The participants were selected based on the individual's knowledge of the phenomena and the ability to answer research questions (Saunders & Lewis, 2018). Accessibility and availability of individuals was a key consideration when they were selected for interviews. A snowball sampling technique was used where a service provider recommended a colleague be contacted to provide further insights into the study. The technique is also recommended by Saunders and Lewis (2018).

4.6 Description of the sample

The study comprised 10 participants with knowledge of GE innovations and experience in the manufacturing industry. Their perceptions and experiences offered in-depth insight into the barriers and promoters of GE adoption. Although the participants have mainly worked in the manufacturing industry, their basic understanding, technical expertise and experience, managerial exposure and knowledge of the GE innovations were different.

Table 1 illustrates a summary of the sample, their designation, specific field of

expertise, gender and age. The participants' names were deliberately excluded from the description, and instead, they were provided unique identifiers, such as Participants #1 to #10, to maintain confidentiality and anonymity.

Table 1

Summary of the sample

Participant ID	Job designation	Professional services	Role category	Age	Gender
Participant #1	Maintenance manager	Provision of maintenance services	Service provider	34	Male
Participant #2	Process specialist	Process design	Service provider	56	Male
Participant #3	Business development manager	Waste management solutions	Service provider	45	Male
Participant #4	Engineering specialist	Mechanical, instrument-tation and electrical DESIGN	Service provider	52	Male
Participant #5	Project facilitator	Environmental studies	Service provider	47	Male
Participant #6	Network studies lead	Plant networks (services)	Service provider	39	Male

Participant ID	Job designation	Professional services	Role category	Age	Gender
Participant #7	Head of projects	Site project management	Company employee	44	Male
Participant #8	Production manager	Site production management	Company employee	46	Male
Participant #9	Chief strategist	Solar energy service provider	Service provider	56	Male
Participant #10	Chief operation officer	Operations management	Company executive	58	Male

4.7 Data collection tool

In qualitative research, the researcher is a measurement instrument owing to the ability to make judgements and influence the study credibility (Golafshani, 2003). The researcher used the interview guide, presented in Appendix 1, as a practical tool to direct conversations during interviews.

The interview guide was developed in-line with the research questions in Chapter 3 to ascertain that the study remains aligned with the topic and that all the selected questions generated from the literature review were answered.

One pilot interview was conducted to test the interviewer's technique, and time allocation for the interview relative to research questions and to test for the functionality of the recording equipment. The pilot test also evaluated if the interview approach was effective in directing participants and establishing if participants were comfortable with how the questions were directed (Saunders & Lewis, 2018). Pilot

interviews were crucial to establishing if there was a need to reformulate the questions (Korstjens & Moser, 2018). During the pilot interview, measurement instruments were tested for functionality and quality. A recording of the pilot interview was reviewed, providing an opportunity for error spotting before the researcher interviewed the main study participants.

After the pilot interview, the interview guide was revised to incorporate new insights in Appendix 2. The most important improvement to the interview guide was to ask participants about their basic understanding of GE. Although the question sounds basic, it was interesting to discover how each participant had a unique observation or understanding of what GE is. The insights that emerged from this question also aided the depth of the literature review owing to the various definitions of GE presented by the participants. Sample suitability was also established by probing participants about their understanding of GE. The open-ended style of questions provided the participants with an opportunity to explain the phenomena from their own understanding and perceptions.

4.8 Data collection process

Data were collected using semi-structured interviews as the researcher aimed to obtain an in-depth analysis of GE adoption promoters and barriers from the observations of experienced participants. Before face-to-face and online interviews were conducted with the interview participants, they had to complete the consent form and permission was requested (Appendix 3) to record the sessions for ethical purposes. Confidentiality and anonymity were kept on data collected from participants, including the protection of personal information (Saunders & Lewis, 2018). The duration of interviews per participant is reported in Table 2 below.

Table 2

Interview duration per participant

Participant ID	Interview duration (min)
Participant 1	30
Participant 2	43
Participant 3	44
Participant 4	39
Participant 5	57
Participant 6	44
Participant 7	46
Participant 8	47
Participant 9	52
Participant 10	39
Average	**44,1**

Ten (10) interviews were conducted with participants. Each interview lasted for 44 minutes on average. Audio recordings were used to record all participants' interviews. The computerised qualitative data analysis software was used to store data as text. Data collected using audio recordings were stored as non-text data. The no-text data was then transcribed into a word-processed document to analyse it as text data (Korstjens & Moser, 2018).

Each participant was directed to the same questions and assisted with the guidelines; however, the sequence of questions varied depending on the insights articulated and to follow the participant's trail of thought. Where participants' responses were unclear, they were directed for clarification by the researcher. The researcher's style of probing for more insights was by playing back what the responded said to align the understanding between the researcher and the participant.

The case study research requires multiple sources of data and, therefore, secondary

qualitative data were obtained as reports and audio recording, which was transcribed into a Word document for easy qualitative data analysis (Grafström & Lindman, 2017).

Qualitative data was progressively analysed after each interview before continuing to collect data from other participants. This was conducted to allow monitoring of the initial insights and to establish if data saturation has been researched (Alam, 2020).

Participant #7 was re-interviewed to obtain more insights on the company's sourcing strategy for GE suppliers. The researcher had intended to interview Participant #9 for more insights on the competitive nature of GE supply; however, he could not avail himself owing to his commitments. The questions were then sent to him to respond to through an email, which he did, and the information was also considered in the study analysis.

4.9 Data saturation analysis

The researcher interviewed various participants within the organisation until data saturation was reached. Data were saturated after interviewing Participant 9. Data saturation is a point at which no new information, themes and codes are generated from data sources (Alam, 2020). It also demonstrates informational redundancy where participants no longer contribute to a new body of knowledge or nothing new has happened. Alam (2020) contends that the number of respondents could be selected by observing data throughout the data collection phase up to where data saturation is reached. Figure 1 demonstrates the data saturation.

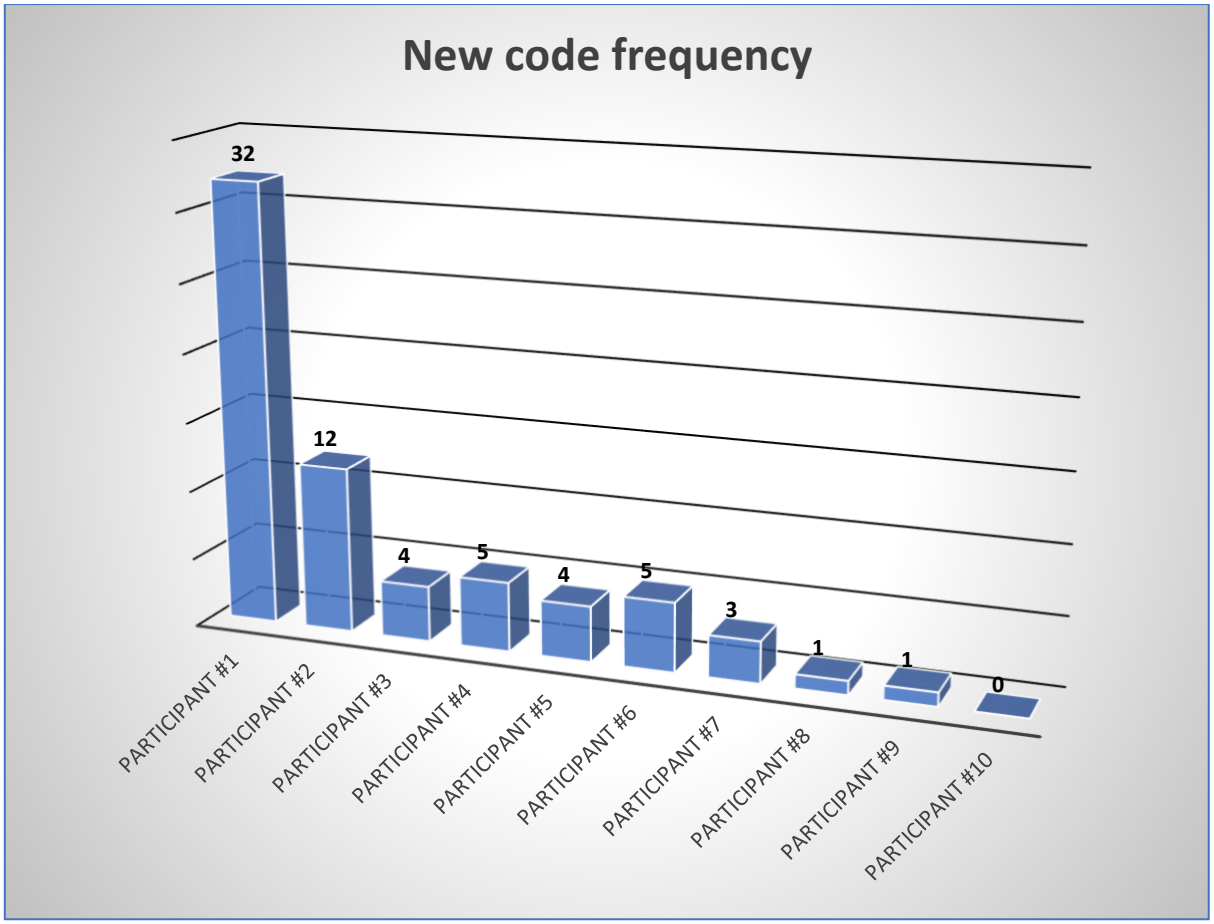

Figure 1

Data saturation analysis based on the number of new codes generated per participant

4.10 Data analysis approach

Data collected during interviews through audio recordings and field notes were stored electronically and backed-up on two computers, the cloud, and on the external hard drive. This was to make sure that data were available when needed, whether the researcher was at work or at home. The files are protected with passwords that restrict access. To generate data for analysis on statistical software, and interview recordings were typed out such that the transcriptions accurately represent the participants' interviews (Korstjens & Moser, 2018). Data transcription constitutes a major data source for the study; therefore, great focus on the accuracy of words representing the participant's interview was critical (Korstjens & Moser, 2018). Each participant's interview was saved, transcribed and coded separately to ensure that

data could be revisited when necessary.

Audio recordings were transcribed using the team's software and saved as Word documents. Word documents were perused with the video recordings, to ensure that the participant's information had been documented accurately. The word documents were put through a data cleaning process to prepare for analysis on the qualitative data analysis software. Word documents were then transferred on to Atlas ATLAS.ti. Software for analysis. During the analyses of qualitative data, the researcher looked for patterns and systematically organised and categorised data to answer the research questions (Korstjens & Moser, 2018).

Data collected through interviews provide information elasticity as respondents provide in-depth understanding and observations of the research phenomena. The researcher analysed such information to develop codes and themes from various observations of the participants (Alam, 2020). Secondary qualitative data, such as non-numerical and documented reports suitable for the study, were collected and analysed to support evidence from respondents and to increase the validity of data.

4.11 Quality controls

In a qualitative sampling plan, the participants are selected deliberately, providing information of high quality to ensure that findings are derived from rich data sources (Korstjens & Moser, 2018). The researcher bias was expected owing to proximity to data sources and knowledge of the manufacturing industry. To limit such biases, a pilot interview was conducted where the participant was directed for feedback to improve the quality of interview questions and the quality of data.

The researcher ensured the data used for analysis was high quality and reliable by using an audible recording device. Secondary data sources, such as reports and business presentations, were used to validate data collected from the participants (Korstjens & Moser, 2018). The most critical part of data control was to ensure that the participants' data were validated using other sources from secondary data and that the recorded data accurately captured and reflected their experience through the critical translation of interviewees' emotions during data transcription (Korstjens & Moser, 2018). The quality and accuracy of transcribed information was reviewed

by revisiting the original recordings of each participant and ascertained that the data were highly reliable and accurately represented.

Data reliability was achieved using the same interview guide for all participants. Qualitative data control was achieved by requesting participants to be available for any follow-up discussions where necessary. Follow-up interviews were conducted with Participants 7 and 9 for clarification and additional insights. The full audit trail is available in case the researcher wants to check with participants and to ensure conformability and dependability (Morse, Barrett, Mayan, Olson, & Jude, 2002). The concept of repeatability, transferability, confirmability, and dependability defines qualitative data quality control, with specific methodological strategies to demonstrate qualitative rigour (Morse, Barrett, Mayan, Olson, & Jude, 2002).

4.12 Ethical considerations

Before starting with data collection, the researcher was given approval by the GIBS ethical committee (Appendix 4) after submitting a write-up of the research methodology as presented in this chapter, an interview guide, a consent from and an authorisation letter from the company (Appendix 5), allowing the researcher to interview participants from the organisation. The participants knew their right to withdraw from the interview if needed, and they were also advised that the interviews were being recorded. The researcher assured the participants that their details would not be disclosed in the data reported for anonymity and to maintain confidentiality.

4.13 Triangulation of data

Secondary data as a voice-recorded presentation and annual report was used to validate the research findings. Interview participants who work for the organisation confirmed that the company is deploying RE technologies, such as solar power and recycling energy from its processes to minimise the pollution of the atmosphere. The participants added that the organization’s sustainability objectives are to lower the carbon footprint by selecting efficient equipment and through the adoption of the GE technologies and the circular economy practices. The sustainability plan has been outlined in the organization’s annual report.

Barry and Healy (2017) contend that a successful transition from fossil fuels to GE technologies requires recognition of the behaviour, strategy, and values of individual actors and policies, regulations, and infrastructure. The organisation's energy strategy has also been articulated in a recorded presentation and published on the company's website. The audio recording was transcribed to extract the energy strategy as it confirmed the interview findings. The main finding from both the annual report and audio recording was that the company has considered solar energy and other TI for recycling energy.

The company's energy strategy

Below are the organization's strategy extracts published on the annual report and company website. The strategy demonstrates the organisation's intentions to transition from coal-based electricity to GE and other TI. The primary message from the energy strategy is that the organisation will not use coal on their manufacturing site. Below is a summary of the strategy extracts.

Annual report extract

"*we have moved away from a linear economy framework and have adopted a circular economy so that we reduce pressure on the use of fresh raw materials and reduce the carbon footprint. When it comes to BoD, we are deliberately selecting equipment that has a lower carbon footprint and opted for processes that do not use coal so that we build and maintain a decarbonized business. Our strategic goal with regards to sustainability is to have the lowest CO2 emissions per metric ton of product produced*".

Website audio recording extract

"For our plant designs, we are choosing equipment that will deliver the highest energy efficiency as well as the lowest carbon foot print.

We will not use coal, instead, we will have solar and gas powering our plant. This will limit our greenhouse gas contribution and also minimise climate change impacts. In addition to recycling waste water within the operations, we will also be turning some of the waste generated from our operations into

products".

4.14 Limitations

The participants are all in the manufacturing industry. The data obtained from a single industry lacks depth from an ordinary population that has no technical experience. The analysis of data by the researcher may be influenced by the researcher's extensive experience in the manufacturing industry, technical know-how and knowledge of the GE innovation phenomenon.

Observing the age demographics of the sample, only one participant is classified as a youth (less than 35 years old). This is mainly because the participants' selection in the project's initial phase was based on extensive experience in the manufacturing industry. Seventy per cent (70%) of the participants offer consulting services, as the company is a greenfield project and requires in-depth knowledge of titanium dioxide manufacturing experience.

Female participants with knowledge of the phenomena could not be found. Only two suitable potential female participants were not available or eligible for interviews. One potential female participant is the researcher, and the other could not be researched for interviews owing to other commitments. The other reason for the shortage of female participants in the study is because women have been excluded from job opportunities in the male-dominated industries, such as manufacturing, and, therefore, female workers are underrepresented in the manufacturing sector (Makochekanwa & Nchake, 2019). Although government policies have driven companies to provide equal opportunities for males and females in all industries, there is still a significant shortage of females with the expertise and experience required for this study in the industry.

Low participation of youth, the absence of female participants and the non-selection of shop floor workers constitute a lack of diversity in the data, which limits the research findings and learnings. The case-based study limits access to interactions with communities and regulators. Discussions about regulatory requirements and implications were limited to a single company context and forfeited insights from similar organisations, policymakers and community perspectives. More insights from

policymakers and the community would have strengthened the research findings. Non-expert individuals offer various perspectives and opportunities to learn more about a problem (Dunphy, et al., 2020).

Saunders and Lewis (2018) contend that close exposure to the case may yield bias in the findings and that one case or a few cases compromise faith in the findings. The researcher is an employee within the organisation where the study was conducted, with technical expertise and knowledge of the manufacturing industry.

This case study research only focused on solar power as a form of renewable technology. GE practices referred to in their area are a mix of energy supplied from renewable sources and recycled or recovered energy sources. Owing to the nature of the operational processes, it is unfeasible to use energy derived only from renewable sources.

CHAPTER 5: RESULTS

5.1 Introduction

This chapter provides findings from all 10 interviews conducted as part of data collection for the research. Data were collected in-line with the primary research question and subsequent questions outlined in Chapter 3. The participant's perceptions were based on their knowledge and experience of the GE phenomena. The research data findings are systematically presented in a table format to demonstrate how the themes were generated and then followed by the analysis of the participant's insights.

For better data organisation, the theoretical research constructs were used to arrange the research information according to group categories. Quotations extracted from each participant were grouped into thematic codes and represented similar ideas and perceptions. The study initially generated 66 codes (Appendix 6), and later merged into 25 codes (Appendix 7) to simplify data analysis. From the 25 codes, 10 themes were developed and mapped under each research question (Table 3, 4 &5). The themes that represented a common set of ideas were analysed under the appropriate research question, and the details of each are outlined in the subsequent sections.

5.2 The primary research question (RQ): *What are the green energy adoption's promotors and barriers?*

Table 2 details the number of codes derived from the research participants, the allocation of code categories for the research question (RQ) and the themes that emerged from the presented codes.

Five themes have emerged under the primary research question (RQ). The themes relate to the research participant's awareness of the GE phenomena, technological innovation barriers, the attitude of various stakeholders towards GE practices, the influence and role of investors and government towards adopting GE technologies.

Table 2

List of codes and themes for the primary research question (RQ)

Code	Number of quotations	Code category	Research question	Number of themes
GE definition	19	GE Innovation	RQ	**Contextualising green in the manufacturing industry #1**
Innovation and adoption of GE technology	40	GE Adoption	RQ	**Innovation of GE technologies #2**
GE innovation installation successes	18	GE Innovation	RQ	
Role of markets, financial institutions and investors on GE adoption	40	GE Diffusion	RQ	**Role of markets and investors on GE adoption #3**
Role of government and legislation on GE adoption	**75**	GE Adoption	RQ	**The role of government on GE adoption #4**
Legislation to enforce green energy	14	GE Diffusion	RQ	

Code	Number of quotations	Code category	Research question	Number of themes
Negative attitude	25	GE Diffusion	RQ	**Behaviour towards GE adoption #5**
Positive behaviour	20	GE Diffusion	RQ	
Promoters of green energy	44	GE Diffusion	RQ	

5.2.1 Theme #1: Contextualising green energy in the manufacturing industry

The study participant's contextual understanding of the GE phenomena was evaluated by directing the RQ, *"what is your understanding of green energy?".* The objective of this question was to determine whether the contextual understanding of the GE phenomena within the manufacturing industry has any influence on the participants' views, perceptions, and attitudes towards the adoption of GE practices.

Nineteen quotations, comprising extracts from each study participant, reflect the recordings. The responses indicated that all 10 participants understood the phenomena within the manufacturing industry context and demonstrated knowledge and experience of GE practices. Their insights indicated that their observations on GE adoption might differ based on the experience, field of speciality and unique knowledge and expertise that each individual possesses.

> **Participant #1** is aware of the GE phenomenon "I mean, people only want to invest in companies now that are not hurting animals or hurting the trees or hurting our future" and defines GE as a method of exploring sustainable ways to produce energy while reducing harm to the environment. His insights of sustainability, "*you look at in terms of sustainable ways of producing energy*", are not limited to the protection of the environment, but he links sustainability to productivity. He contended that cost should be primarily allocated to activities that yield higher production output and that adopting GE will take less priority if it does not save costs for the organisation.

> "*I put my capex on things that will help me save cost, that's where most of the time money is channelled*". *That's why things like green energy and investment on green energy tend to take a back seat. That would be the main barrier I think*".

The participant observed cost-saving as the main barrier to GE innovations adoption and, therefore, his awareness of the GE phenomena does not influence his attitude towards GE adoption.

> **Participant #2** does not think that defining GE is important. *"I think it's a good buzzword, green energy. I'm sure you've got different definitions if you speak to different people". "So, I'm not sure it matters actually, what matters is that we put less CO_2 into the atmosphere".*

The participant, however, is aware that carbon dioxide emissions are harmful to the environment and that focus needs to be provided to reducing carbon dioxide emitted into the atmosphere.

> "*I'd focus more on what's really being done than saying we are zero emissions, or we are transferring to green energy*".

He further added that it is impossible to generate energy without affecting the environment, as the manufacturing processes for GE technologies pollute the environment.

> "*Wind energy, there is energy that's generally consumed, presumably from largely fossil fuels in building turbines*".

The participant remarked that the adoption of GE requires capital and that availability of funds would expedite the adoption. His objective is to increase productivity and therefore, GE adoption takes less priority compared to productivity.

> "*Companies are driven by the by the markets and profitability*".

The participant believes that zero carbon dioxide emission is unachievable and that GE technologies are costly to implement. The technical understanding of the GE phenomena by the participant contradicts the norm and is the barrier to GE adoption.

Participant #5 supports Participant 2 concerning not limiting the GE definition to

energy generated from renewable sources. The participant explained that producing GE means producing energy while recovering the carbon dioxide emissions.

> "*The green energy for me is energy that is sustainable. "So, in other words, that whatever we're burning, we're able to recover*".

The participant also emphasised that the aim of recovering the emissions is to minimise the rate at which natural resources are depleted. The contextual understanding of GE practices by the participant influences whether they adopt GE technologies.

Participant #10 defined GE as energy derived from renewable sources and explained that energy might not be green if it means the sources involve destroying trees, animals, vegetation and digging up the ground.

> "*Is energy that is generated from sources that have none or that release minimal or no degradation to the atmosphere*".

All raw materials originate from a natural source, or a source generated from another natural source. The natural ecosystem contradicts the participant's understanding of GE, and, therefore, the contextual understanding of GE phenomena by the participant influences decisions by the organisation about which energy technologies are to be considered in their processes.

5.2.2 Theme #2: Innovation and adoption of green energy technology

The study participants shared insights on GE technology innovations. The participants mostly knew of solar energy rather than other types as the organisation mainly adopted solar energy technology. They have also included recycling technologies in their energy consumption model to minimise using national grid energy. This analysis aimed to determine how technology innovations affect the rate of GE adoption. Sixty-one quotations were extracted from the interview data and arranged according to codes and themes.

5.2.2.1 Green energy technology and adoption

According to **Participant #7**, the organisation partnered with a supplier with the ability to finance own solar project and only interface with the organisation when supplying power to the manufacturing plant

> "*So, the ability to finance translating to the cost of the power, which comes with the cost of financing were quite key to us*.".

The criteria for selecting the solar supplier were not only based on their ability to access financial resources but also the technical competencies in solar technology application. Applying solar energy on an industrial scale is not common in the South African manufacturing industry.

> **Participant #10**, "*The entity that we have now is strong in Europe*".

This means that the supplier could only demonstrate his capabilities through operations outside South Africa.

> **Participant #7** indicated that choosing the supplier with technical and demonstrated capabilities and experience was critical to the business. *"The ability to demonstrate working installations with a high uptime was critical".*
>
> **Participant #9**, the supplier of the solar power, alleged that although he has demonstrated knowledge and competencies in producing solar energy, he should select the right equipment compatible to the South African climate, to ensure longevity and efficiency of power supply to his customer *"So the equipment selection is very critical and compatibility to the location. The conditions and location are also critical for security purposes".*
>
> Although the chosen supplier demonstrated the capability to supply solar energy to the organisation, **participant #7** explained that solar energy will only be supplied during daytime and when the sun is available *"So that talks to the 30% and the starting solution will be a day only solution".* Availability of the sun is the determinant of whether the supplier can provide solar energy to the production plant or not.
>
> **Participant #5** contends that advancing technology innovations may affect the rate at which the organisation adopts GE technology. *"I think technology is moving at a very fast pace and again technology, in my view is pushed by*

innovation which is pushed by the need". The need for continuous supply of solar energy should drive innovation of effective solar storage infrastructure.

5.2.2.2 Green energy innovation installation success

The study participants indicated that their exposure to successful solar energy installations was mostly on a residential and retail scale but not on an industrial level.

> **Participant #2**: "*I managed to reduce my electricity usage in my house by 25%, by basic things like timers and geezers, converting from expensive lightbulb".*
>
> **Participant #4**:" *the successes were more not in business or manufacturing sites". "there were more to do with retail offices*"
>
> **Participant #8**:" *Solar has been embraced more on a domestic scale*"

The lack of familiarity and minimal exposure to successful solar energy installations affected consumer confidence and resulted in low adoption of GE technologies. The organisation will consume 10MW of solar energy to commission its newly designed plant, which has a power demand of 30MW. The barrier to complete adoption of GE is the lack of exposure and unavailability of successful installations of solar energy plants in South Africa.

5.2.3 Theme #3: Role of markets, financial institutions and investors on green energy adoption

The organisation in this study has resumed its product development operations and securing funds to construct a titanium pigment production plant. The nature of its manufacturing processes requires extensive usage of energy. Similar plants in Europe, Asia and other countries use conversational processes to extract valuable metals, and the processes involve coal to fire the steam turbines and heat the kilns. This organisation's power consumption strategy exclude coal from its processes and opted to take a unique opportunity to design the power supply using a hybrid model.

> This is a greenfield project that has attracted international investors. **Participant #10** explained that the investors interested in this project had outlined their requirements for environmental sustainability *"We are have*

tapped into the international market for finance and a lot of those organizations do have signatories to some of these initiatives to save the planet and we see those requirements coming through as part of their funding requirements or funding conditions". In this context of a new manufacturing plant, the investors play a critical role of promoting the GE practices.

Participant #7 added that the investors have stringent requirements on green energy practices, supporting the statement made by **participant #10**. ***"****The likes of IFC or the World Bank in particular, you've got quite a stringent framework on these items, so we subscribe to those and we take guidance in terms of targets and so on from them as well".*

International Finance Corporation (IFC)'s role had a significant influence on the organization's attitude towards GE adoption as highlighted by both **participant #7 and #10**.

Participant #1 who provides maintenance services to the company and other organisations alluded that it is now a common practice for investors to prioritise GE requirements in their strategies *"investors now there's also an investment strategy towards investing in companies that have ESG focus".*

Participant #9 has emphasised that the that funders are also happy to invest in businesses privately producing power and selling it into the markets. *"major financial institutions are keen on funding green energy operations".* The participant further adds that market conditions especially in the EU regions have establish green products requirements. Which means organisations need to focus on producing green products if they aspire to grown and trade international. *"selling to the EU and the US markets provide incentive". "The markets in this age, they give you opinions, they can stop buying your products if your existing product is not green."*

Participant #6 collaborates with a network of manufacturing firms and suggested that the markets are increasingly driving the diffusion of GE adoption. *"And client requirements are coming up to have more green associated products". So, any product that has ability to demonstrate that it has a component of sustainability and renewable energy, or green energy supplied to it can gain a commercial advantage to products that do not show that".*

Participant #10 remarked that it was important to incorporate GE technologies at the design phase of the project to attract the target market for

the organisation. *"So, in order to be desirable to target market in the industry that we are in, it was important for us at the onset of our design to consider green energy".*

The investors, financial institutions, and markets are, therefore, crucial drivers of GE diffusion and ambassadors of a sustainable environment.

5.2.4 Theme #4: Role of government and legislation on green energy adoption

The South African legislation has incorporated a carbon dioxide emissions limit for all the manufacturers whose processes rereleases greenhouse gases. The study participants felt that the government had not enforced penalties on firms that exceed their emissions limit.

In **Participant #2**'s view, there are no cases of plants that closed because the operator violated the environmental legislation. *"I don't see visible examples from government adopting punitive measures.".* "*From the legislation to enforcement, well, there isn't a precise expectation that companies will adopt it, and there isn't encouragement".* The participant perceived the government as a barrier to GE adoption.

Participant #9 had a diverse observation of the government's role in GE adoption. As an independent power producer and supplier of GE to industrial customers, the participant observed government actions of allowing independent power producers more capacity to supply the market as a promoter of GE practices. *"this is now the regulation playing a very important role".* He believes that the legislation had been a barrier in the past few years; however, changes to the permit requirements and recent adjustments to allow independent producers to generate more power have been well received by suppliers. *"the regulation later was quite ok"*.

The observations of **participant #10** also lean towards categorising government and legislation as promoters of GE adoption. "*As you will know, there's been many pronouncements that they've increased the threshold where certain licenses and requirements are needed*". The participant believes that the government's initiatives to relax power production requirements and conditions must be motivated by recent events of national power supply shortages from its utility company. "*But they are definitely a*

promoter at this stage. I guess it's been accelerated by the pressures that their utility company is failing". "*So, they have now have moved quite aggressively to promote these kinds of alternative and energy sources*".

5.2.5 Theme #5: Behaviours towards green energy adoption

The behaviours of various stakeholders may hinder or promote GE adoption. The participants shared their observations on the behaviours affecting the diffusion of GE technologies. The participants' tone, reasoning, body language, and manner of responding to interview questions were observed to analyse their attitude towards the GE adoption concept. All participants demonstrated energy and good depth, and passion for the topic. Capitalism and the drive to make money seemed to be the main factors prohibiting GE adoption.

Participant #2 earlier eluded that productivity is a top priority over GE practices. *"Companies are driven by the by the markets and profitability".* He further suggested that his performance objectives are measured by how much product he has produced relative to whether he implemented GE practices or not. *"The demands for me as a plant manager were to be more efficient and if I could achieve the objective then after be greener as a side benefit then that was also good".* The participant believes that individuals are slowly feeling pressure to embrace GE technologies and are showing commitment towards complying with environmental regulations. *"I think they're doing it because they can see that at some point in the future it's going to be an economic payback or there's going to be an expectation".* The participant did not demonstrate a strong will to try to adopt GE practices; however, he recognises the power of collective efforts towards limiting the influences of pollution in the atmosphere.

Participant #2, "*To adopt green energy globally comes at a cost and it requires the whole of humanity to work together and to co-operate towards a common objective. Objectives on an individual level is to make profit*".

Participant #1 contends that investors can also be a barrier to GE adoption. "*those guys always look at the bottom line and the bottom line have to grow, or at most not go down right?" "So, the behaviours on investment is always geared towards returns*". He added that the primary objective of investment is to generate returns; however, GE technologies are not immediately profitable, and require a huge capital investment.

Results for Research Question 1 (RQ1): *What motivated the company to consider green energy technologies?*

The participants demonstrated in the previous sections that the organisation considered GE innovations for their manufacturing plant. The organisation has considered solar technology as the source of GE to the production plant. Table 3 below represents codes used to analyse motivational factors that led to the company's interest in incorporating GE technologies and practices into their operation. Three themes emerged after merging several codes to simply analyse the research data. Sixty-three quotations made up the codes used to develop themes. The themes under this RQ are the adoption of innovation in a new operation, affordability of GE technologies and the capabilities of solar energy suppliers.

Table 3

List of codes for Research Question 1 (RQ 1)

Code	Number of quotations	Code category	Research question	Theme
Advantages of green field projects	70	GE Innovation	RQ 1	**GE innovation adoption in a new operation #6**
Affordable technology	60	GE Adoption	RQ 1	**Affordability of GE technologies #7**
Adoption of GE innovations from suppliers	55	GE Adoption	RQ 1	**The solar energy supplier capabilities #8**

5.2.6 Theme #6: Green energy innovation adoption in a new operation

The new plant has an opportunity to exploit and adopt GE technologies throughout the operation; however, they have opted to resume with 30% of solar energy, whereas 50% of power will be the base load supplied by Eskom.

Participant #7 emphasised that the organisation will supplement its 20% of

power demand with recycled energy from the exothermic production plant processes over and above the 10MW that will be generated as solar energy. *"if we implement a solution as we anticipate that's nearly half the capacity that we need". "So, what will happen is half of our capacity will be coming from solar and off that steam generator".*

The organisation designed its own power consumption hybrid model never tested before in a South African context—30% solar energy, 20% recycled energy and 50% fossil fuels energy supply. The analysis of this theme intends to determine how the advantages of newly designed manufacturing plants have motivated the organisation to adopt GE technologies. Provided the technology era and the state of innovation advancements in the markets, the study participants have emphasised the advantages of a new manufacturing plant as follows;

Participant #1 indicated that the availability of the sun is one of the major motivators driving the diffusion of solar energy. *"there's nothing more available than the sun". "Sunlight is freely available.*

Participant #3 emphasised that it is the technology innovation advantages that a new operation can exploit that motivated the organisation to adopt GE innovations *"Your new business and your products are based on the latest state-of-the-art technology where some operations that have been going for the last 20-30 fifty years, their technology is obsolete or the technology is outdated".* This advantage gives the organisation a competitive edge over its peers.

According to **Participant #10,** the production plant is designed with the ability to adapt the power consumption to various scenarios depending on the operational and external challenges that may arise. *"a new company and we can design everything the way we want it from scratch, unlike an existing company that now is to retrofit the technologies".* The hybrid model allows the production plant to use various energy sources.

Participant #5 indicated that pursuing solutions for customers motivates the organisation to be innovative *"we are motivated because we are looking for solutions for the toughest clients". "We're constantly devising better processes and better engineering".*

5.2.7 Theme #7: Affordability of solar energy

This analysis established whether cost-saving was a driver for the diffusion of solar energy technology in the context of the newly designed manufacturing plant. It is a no-brainer that organisations seek opportunities to reduce operational costs, and this firm is not an exception to such cost savings ideas.

> **Participant #1** emphasised some of the cost-saving opportunities presented by adopting solar energy technology. "*In terms of my manufacturing cost, I don't have to pay for the cost of tariffs and supply and transmission lines and all that".*

The latest technologies and designs allowed the organisation to exploit any existing idea that can reduce its operational costs.

> **Participant #4** explained that advancing solar energy innovations has reduced the cost of solar energy technologies "*Cost of solar power today versus what it was five years ago has reduced in price and their efficiencies are better".*
>
> **Participant #5** supports the assertion that as innovations improve, the cost of technology becomes affordable and induces motivation for end users. "*TVs and PCs and those kinds of electronics, they are consuming much less energy than they used to because the technology is improving*".

5.2.8 Theme #8: The solar energy supplier capabilities

The aim of analysing this theme is to assess how the supplier capabilities have influenced the organisation to adopt GE innovations for its manufacturing plant. Evidence from the study participants has revealed that GE technologies are not well tested, and that poses a risk to customers. Such risks will be explored further in the subsequent section.

> **Participant #4** contends that the adoption of GE technology is made on faith rather than experiencing *"4 leap of faith of accepting that this is going to work for you".* He further contends that the suppliers have not earned a good reputation in the South African market. *"The reputation of industry is decided by the bad suppliers. That's I have known of a couple of companies that have been bitten or poorly installed".*

Participant #10 also indicated that the GE technologies are trial and tested in other countries but not locally. "*energy or green energy solutions, so these are tried and tested concepts not in Africa but certainly in the rest of the world*".

The ability of the GE power supplier to demonstrate the knowledge and competencies for energy generation provided the organisation confidence to consider the innovations not well-tested in the South African manufacturing industry.

Participant #10 has confidently expressed excitement and enthusiasm about the supplier's capability. "*There is more than sufficient evidence to demonstrate that what we are looking for and what we require is well managed and can be comfortably supplied*".

Although the organisation will adopt only 30% of its energy from the solar systems, 20% from recycled steam and 50% base load from the national grid, **Participant #10** indicated that the organisation intends to make a complete transition to GE as soon as conditions permit. *"the solar producer is they can generate up to 100% provided they can obviously get the space that they need because unfortunately these things need space and space at the moment is at a premium".* The suppliers have an opportunity to improve their innovations to include technologies that will provide uninterrupted power supply and storage for back-up with an intention to provide 100% of GE to the manufacturing plant.

Participant #7 supports the evidence that the company will use only 50% of the power generated from the national grid during plant commissioning. *"meaning 50% can be generated from all these combinations we've spoken about".* The other 50% is solar energy and recycled steam energy form the production plant, as emphasised in the above section.

The ability for the organisation to collaborate with more suppliers will ensure that they can ramp up solar energy usage as soon as the suppliers have the capabilities to supply more than 30% of their energy demand.

Participant #7 elaborated on the engagements made with various suppliers. "*We find quite a number of people interested. We have got already a partnership for this phase that we are building, but we have had interest from other suppliers*". The participant has indicated that the company stays open to taking up more GE from suppliers "*So if someone comes across and is able*

to build a solar plant close to us and be able to supply that power to us we still have the capacity to take that power"; however, he makes more emphasis on their competencies and the company's selection criteria to ensure that they have capabilities to supply the production plant. "*And we do interrogate their solutions at a technical level just to give ourselves a sense of the capacity, the reliability and the robustness of their solutions*".

The organisation was motivated by the advantages presented with the newly designed manufacturing plant to adopt GE practices. The new technology innovations, affordability, competency, and experience of the suppliers providing solar energy motivated the organisation to adopt GE practices.

5.3 Results for Research Question 2 (RQ2):*What risks are the company exposed to, hindering the complete adoption of green energy practices?*

The risks emphasised in previous sections are analysed under this RQ to understand further the factors that prohibit GE adoption. Similar to other sections,

Table 4 summarises codes derived after merging the initial study codes. After merging the codes, a theme was developed to allow for data analysis. Three themes emerged under this RQ, and each theme is analysed independently.

Table 4

List of codes for Research Question 2 (RQ 2)

Code	Number of quotations	Groups	Research question	Theme
Expensive	55	GE Adoption	RQ 2	**GE technologies are perceived as expensive #9**
Risks	138	GE Adoption	RQ 2	**The risks of adopting GE technologies are higher than the rewards #10**

5.3.1 Theme #9: Green energy technologies are perceived to be expensive

This research theme may contradict research theme #7 at face value; however, the context of affordable solar energy in section 5.3.2 refers to the cost-saving realised from using solar technologies and not the cost.

This section focuses on the cost of GE infrastructure and the initial investment to acquire such expensive technologies. What makes solar energy affordable for this organisation is that the supplier and not the manufacturer carried the infrastructure capital investment. The manufacturer will purchase power from the supplier at a rate less than that of the national utility company.

This section explored whether the cost of GE infrastructure influences adopting GE practices in the organisation. The participants believe that the infrastructure for GE storage is expensive.

> ***Participant #6:*** has emphasised limitations of solar energy supply as the unavailability of the sun and that the cost of energy storage technologies is too high. *"You can only generate solar energy when the sun is shining as an example, and then you can use other methods for storing it, but that comes at a cost.*
>
> **Participant #2** believes that consolidated efforts and alignment globally would facilitate the diffusion of GE technologies. He contends that as it stands, each

country regards itself and focuses on implementing profits instead of joining hands to make things easier for other countries to afford the technologies, especially in the Africa continent. *'' to adopt green energy globally comes at a cost and it requires the whole of humanity to work together and to co-operate towards a common objective".* The participant added with more insights around the wave technology and contends that although the waves are readily available, it is the cost of expensive technology. *"with the wave technology it's the cost of implementation and I would think that maintenance and reliability would be difficult, although the waves are already always there."*

Participant #4 explained that the return on investment for GE technologies takes time "The time for your return on investment is long". "*You've got to get through that, and then once you've paid it off, then you gain profit*". The investment requirements and the lack of competencies to produce its own GE, led to the decision of the organisation to not take the risk of owning a solar plant or any plant that generates GE.

The organisation chose the option emphasised by **Participant #6** to avoid the need for capital investment in GE. "*The other option is to buy it as a service from someone that you're buying it like you're buying your electricity from Eskom"*.

5.3.2 Theme #10: The risks to adopt green energy technologies are higher than the rewards

This section explores risks emphasised by the study participants in the previous sections. Two major risks were identified and explored under this theme. The risks led to the company adopting only 30% of its power requirements from the solar system. The risks involve unfamiliarity and lack of skill to design and operate a RE plant.

Participant #10 emphasised that the organisation will continue outsourcing RE services for the foreseeable future as they would rather avoid dealing with infrastructure innovation developments, capital investment and investment in developing technical skills to run an energy production plant. *"And these technologies, as you know, evolve and change very quickly. I mean, the solar panel of today is not the solar panel of five years ago, that's how quickly the technologies evolve, so we have no intention of owning a solar pack, we have every intention to continue to outsource these kinds of utilities."*

The other risk revolves around the inability to obtain a continuous power supply from the solar plant. The technology for the storage of solar energy is expensive. The existing suppliers have no financial means and expertise to acquire such technologies.

> **Participant #6** suggests that it is safer for the organisation to use grid energy as a base load to avoid production interruptions as the plant uses continuous processes to manufacture its products *"if your plant depends on a stable, reliable supply the whole time, it is most likely better to be grid-connected so that you can get a stable supply".* The participant further explains the risks about the solar energy power supply. *"Renewable energy is inherently variable but it's reliable. The facilities themselves are fairly reliable. It is just in the sense that you can't rely on them necessarily producing the energy when you need it. The energy is produced when it is available".* This risk necessitates energy storage innovations that are not yet offered by the existing suppliers and are expensive.
>
> The risks of interrupted energy supply to the plant are much higher than the solar energy rewards as power interruptions may lead to the plant shutting down. **Participant #2** emphasised that the plant the organisation is constructing cannot afford power outages. *"running a TiO2 plant in the load shedding environment is a disaster".*

5.4 Conclusions

The lack of a locally demonstrated and successful solar plant installation affects the rate at which consumers will adopt GE technologies. Evidence from the study participants supports the idea that RE technologies are the main solution to combat the global warming effects and that solar energy is the most familiar and preferred form of RE. The organisation in the study has embraced and accepted its responsibilities on climate change and is aided by its markets and investors to focus on GE solutions.

Although the participants confirmed that solar energy technologies have become cheaper, the company would rather outsource the solar energy power generation to a capable company equipped to produce solar energy as it does not have the skills and capabilities to run a solar plant. Installation costs for solar energy and form of

GE were high— another reason for the organisation to outsource the supply of GE.

While solar energy is cheaper, evidence from the study revealed that storage technologies are expensive and require a big piece of land to set up the equipment. Energy storage facilities require a huge capital investment which most companies do not have. A literature study supporting this finding has emphasised that mitigation for the lack of continuous energy supply is to store GE; however, the storage technologies are expensive (Su, Pang, Tao, Shao, & Umar, 2022).

The strategy to outsource the solar energy supply is to mitigation of the technical risks, such as lack of technology know-how, experience in power generation and lack of capital funds. The return on solar plant infrastructure investment may be realised only in the long term, and consumers are bound to go into a long-term agreement to aid the supplier with recovering the cost of investment.

CHAPTER 6: RESEARCH FINDINGS

6.1 Introduction

This chapter aims to analyse the collected data along with analysing whether the findings from the interview participants were aligned with the literature review findings or not. The study results also add on the innovation of diffusion theory. An analysis of the participants' data is mapped against RQ, and the findings from each RQ are discussed in this section.

To answer the RQs, the themes derived during data analysis are used to structure the findings. The themes are findings summarised by merging the codes for the presentation of common ideas.

6.2 Discussion of results for the primary research question (RQ): *What are the green energy adoption's promotors and barriers?*

Five findings from the research data are summarised and categorised as themes. Each theme represents the findings acquired from the research data.

6.2.1 Theme #1: Contextualising green energy

The research findings revealed that the understanding of the term GE by the study participants differs across a spectrum of manufacturing professionals. The understanding of the GE phenomena may influence how end users perceive the GE innovations and if they will adopt the innovations. There were mainly two distinct variations of how the participants described the phenomena.

Seven (7) out of ten (10) participants described GE as energy produced from renewable sources or sources that do not release carbon dioxide into the atmosphere. This finding supports the literature study definition of GE by Qin, Sˇkare, Wang, & Xu (2022). Three (3) participants, however, had a diverse observation on GE. They observed GE as energy produced without emitting carbon dioxide into the atmosphere, but not necessarily being produced from renewable sources. The participants contended that if carbon dioxide is produced and recovered without polluting the environment, then such a process could be considered green. The

participants specifically contended that they did not observe renewable technologies as green because the technological components of such technologies are manufactured from sources that emit carbon dioxide. Another participant contradicted this assertion, as he contended that any process that involved extraction of natural resources, chopping of trees, and hurting animals is not green. This argument goes back to the notion that all materials are made from natural resources and RE technology components are also made from natural resources or even sources that emit carbon dioxide.

The participant who explains GE as energy produced without emitting carbon dioxide into the atmosphere supports the net zero carbon dioxide emissions concept, which speaks about recycling and removing carbon dioxide from the atmosphere. The concept is mostly recognised as one process suitable for reducing the influence of global warming (Davis, Lewis, Shaner, & al., 2018).The organisation adopted both solar energy technologies (30% of its power requirement) and circular economy technology (20% of recycled energy) to reduce its carbon dioxide footprint. The hybrid design model allows the operation flexibility to source energy from various sources, although the base load is still on the national grid. According to the literature, GE innovation models have not been developed (Grafström & Lindman, 2017). The hybrid power consumption model concept adds to the literature as a new way to manage the reliability of power supply provided country's power supply challenges.

6.2.2 Theme #2: Innovation and adoption of green energy technology

Solar energy is the most familiar GE technology adopted in South Africa (Dwivedi, Kapoor, & Williams, 2014). Data from the study participants supported this finding. It has been reported that 30% of solar energy has been adopted, whereas 20% of energy will be generated from an exothermic reaction in the manufacturing plant. Familiarity with solar technology has not increased its diffusion rate, as the end users are still extremely critical of the risks and less confident in the technology's reliability. This finding challenges the implications of the diffusion of innovation theory, suggesting that innovations may be commercialised after marketing of such goods or services (Grafström & Lindman, 2017); however, the findings indicated that the marketing of innovations may create an awareness; the participants illustrated that

awareness does not drive the adoption of innovations.

Awareness empowers consumers to critically analyse the innovations and may result in their rejection or slow adoption. Ahmad, Jabeen, and Zhang (2021) suggest an example of how consumers refused to adopt nuclear energy despite a clear awareness of its benefits. This was owing to the safety risks that the technology could present. The risk aversion of the organisation was clearly informed by the knowledge of solar energy limitation. Green energy innovation diffusion depends on the reliability of power supply, based on the study findings. The power supply reliability will increase the rate at which the organisation adopts solar or other green energy technologies.

The participants emphasised that the organisation intends to adopt 100% of GE. That depends to the ability of suppliers to provide uninterrupted power supply attributable to the continuous production processes. Rapid changes in solar technology innovations contributed to the decision by the organisation to outsource GE instead of owning a power production plant. Power production is not a co-competency for the organisation and, therefore, the supply of GE depends on the external supplier. Although the organisation mitigated the risks of producing its own power and against the risk of installation failures, the solar plant will be directly connected to the plant which means the organisation will still be exposed to financial risks owing to a shortage of supply in case of failure. The risk of supply outside the control of the organisation introduces an additional risk that requires a mitigation plan.

Solar energy innovations have not been demonstrated on an industrial scale in South Africa; the suppliers explained that this influences the rate at which organisations adopt GE and prolongs the negotiation process as the customers require extensive verification of supplier capabilities before appointing them. The organisation also conducts extensive diligence and technical verification to ascertain the supplier's capabilities. Familiarity and exposure to the real-life success stories of GE innovations cannot be demonstrated on the South African industry scale. The study's findings suggest that the familiarity concern puts doubt in the capabilities of local suppliers and their competencies in producing GE. These findings are supported by Dwivedi, Kapoor, & Williams (2014) as they contend that knowledge is a key

characteristic of GE innovation and an individual's knowledge about the innovation determines the success of implementation.

The decision by the organisation to outsource power from an external supplier shifts the risk of failure to the supplier. The suppliers of knowledge and skills to produce GE enabled them to mitigate the risk of failure. Ahmad, Jabeen, and Zhang (2021) also contend that the consumer perception of GE technologies, whether in a household setting or industrial application, plays a key role in adopting the GE technologies. It is also known that countries far from innovations may take a long time to adopt the technologies (Noseleit, 2018). Countries that lack TI may experience a slow adoption rate, as evident in South Africa and other African countries.

6.2.3 Theme #3: Role of markets, financial institutions, and investors on green energy adoption

For a new manufacturing plant, funding had to finance product development activities and purchasing of machinery, manufacturing technologies, the utility infrastructure such as power plants, water treatment facilities and waste handling plants. The participants alluded that the organisation is funded by international banks and plans to acquire more funding as the project progresses. They further added that International banks such as the IFC have taken an interest in investing in the project.

IFC is a global bank and a member of the world bank group. The bank focuses on expanding the private sector in developing countries while excluding projects that use fossil fuels as their core energy for production plants (Cicero, 2022). The IFC, through its green bond programme, is affiliated with climate change initiatives and sets out climate change requirements for its customers globally. This finding was supported by the participants as they explained that IFC has stringent requirements when it comes to the sources of energy for the organizations they are funding.

This is one of the several reasons that motivated the organisation to adopt GE practices. The funders have been motivated by international forces to adopt GE practices. The participants did not draw a link between the government's role in promoting GE practices through international banks and other investors and GE's

adoption success. Although the government has aided in promoting GE technologies in this context, its relationship with the investors was not explicitly delved into by the participants.

The participants strongly believed that the function of investors promoted GE initiatives in this study; however, there was no depth shared about what drives investors to promote GE practices. There were strong observations that investors' primary objective in business is to make a profit. The argument about the investor's role in the manufacturing industry may sound contradicting when listening to various participants.

The participants further indicated that international markets such as the United States and EU provide an incentive for green products; these are some of the major markets that the organisation is targeting. Matsuo, Steinemann, Schmidt, and Steffen (2018) emphasised that the international market and investors are driving manufacturers to produce green products; however, the local policies need to support the international drivers to promote GE adoption.

6.2.4 Theme #4: Role of government and legislation on green energy adoption

Government regulations on environmental emissions should curb the adverse influence of greenhouse gases on global warming—majority observed the government’s role in enforcing compliance with environmental policies as critical to promoting adopting GE technologies. The participants believed that the government is not actively enforcing the measures to force industries to follow its environmental regulations.

Eight (8) participants attributed the slow adoption of GE technology adoption in South African manufacturing companies to government policies, either not explicitly specifying GE requirements or the inability to implement punitive measures. The role of government has been observed in two contradicting ways by the participants. Some believe that government is a barrier to GE adoption, while two participants (a solar energy supplier and the company executive) directly involved with the government in this project, had diverse observations on the government’s role in this

context. The participant's observations, however, only focused on the context of the governments in a new operation facility and ignored such a role in the existing or old manufacturing plants. In those instances, the government may seem to slow down adopting GE practices or being lenient on environmental compliance in a quest to save jobs. It has been emphasised that some existing production plants may need to be decommissioned to comply with the environmental regulation (Bischof-Niemz, Calitz, Mushwana, van Heerden, & Wright, 2019), and for this reason, a significant number of South Africans would lose jobs.

In the observation of the two participants, the government has played a significant role in promoting GE adoption for the manufacturing plant in the research. The involvement of the government in the project created opportunities for the organisation and the supplier to establish their manufacturing infrastructure within the same industrial development zone. The proximity of both the manufacturing plant and the power generation plant has created ease of access for both parties and will enable the companies to communicate, produce and consume energy effectively. Recent developments regarding increased capacity for independent power producers (IPP) in South Africa have motivated the supplier to consider increasing the solar energy supply to the customer soon.

Stucki and Woerter (2016) support the finding that the government's role in GE technology adoption is critical but contend that the benefits are mostly public rather than private. The literature study further added that GE technologies are slow at diffusion because companies are unwilling to pay for technologies that have no direct benefit to them (Stucki & Woerter, 2016). While this finding might be true for other organisations, according to some study participants, the argument contradicts the research findings in that the participants (solar energy supplier and the company executive) observed adopting GE as beneficial to their business and will adopt the technologies. The function of government in this context promotes GE adoption.

6.2.5 Theme #5: Behaviours towards green energy adoption

The participants in this study have acquired extensive manufacturing knowledge and expertise from previous companies they worked for. Their experiences with GE practices were mainly drawn from their previous roles in various companies. The

organisation outsources most of its services from various industry experts during this project phase. The manufacturing plant is yet to be constructed; however, the permanent employees are mostly involved with product development activities and project management for the main manufacturing plant.

Although the participants provided inputs based on the organisation's activities in the study, their reflections and attitudes were mainly based on previous experiences. According to the participants, businesses need to generate profit to remain operational. One participant mentioned that his key performance indicators (KPIs) in the previous role were based on productivity and not GE adoption. He observed productivity as a key business objective compared to GE and indicated there was no incentive for him to prioritise GE adoption over productivity.

The participants also indicated that the demand from investors to generate returns on their investment drives companies to prioritise productivity. As an individual, some observed that the participants were more leaning towards a capitalist approach to conducting business. The powerful willingness to approach environmental issues and potential consequences of climate change were not demonstrated by some participants, although they are highly aware of global warming concerns.

On the organisational level, the company has taken its responsibilities towards protecting the environment and demonstrated the intention to reduce the influence of its operational activities on the environment. The intentions are stipulated in their policies and published on the company's website and annual reports. Barry and Healy (2017) contended that a successful transition to GE requires recognition of the behaviour, strategy, and values of individual actors, policies, regulations, and infrastructure.

6.3 Summary of results for the primary research question (RQ)

Although a lack of awareness of GE practices has been identified as one barrier to GE innovations adoption (Grafström & Lindman, 2017), the research findings do not support this assertion. The research participants are all aware of the global warming challenges and that GE practices offer solutions to mitigate global warming; however, the participants have identified other factors they perceive to be hindering adopting

GE technologies.

The study findings demonstrate that rapid changes in TI, a lack of knowledge and accessibility, and a lack of demonstrated ability to produce GE locally might deter end users from adopting GE technologies. The user demonstrated sensitivity to the risks of new technologies by outsourcing GE power production. The role of government, the markets, financial institutions, and investors are critical for GE innovation and diffusion, while local policies are required to support adopting the technologies (Stucki & Woerter, 2016). The study and the literature well-support this finding. Conversely, the function of investors in promoting GE technology adoption has been supported by some study participants, whereas others believe investors prioritise profits.

The research findings suggested that the individual's previous experiences affected their attitude towards GE adoption. In this context, the employee's exposure to GE practices and how the company approached climate change has affected their behaviour and observations of GE technologies. The behaviour of individuals and business strategies were the promoters of GE adoption. This finding is supported by the study of Barry and Healy (2017) as they contend that the business strategies, behaviours of individuals and policies may affect adopting GE technologies.

6.4 Discussion of results for research question 1 (RQ1): What has motivated the company to consider green energy technologies?

The study summarised four factors that motivated the organisation to adopt GE technologies. This includes affordability of technologies, supplier competencies, knowledge, and capabilities of GE technologies.

6.4.1 Theme 6: Green energy innovation adoption in a new operation

The adoption process is defined as the organisation's decision to demonstrate evidence-based intervention and committed to solving a set problem (Lundblad, 2003) The organisation has demonstrated its awareness and willingness to adopt green technologies. Evidence collected during interviews with the study participants revealed that the organisation has considered both the circular economic concept

and RE technology as its strategic plan to ensure that its operations induce less harm to the environment and to ensure long-term sustainability for the business. The circular economy and RE technologies have been adopted to ensure that the company can comply with all the legal and environmental requirements.

The executive team has demonstrated prime motivation towards ensuring that less carbon dioxide is emitted into the atmosphere during its manufacturing operations. Based on this finding and the definition of the adoption process from the literature, it can be concluded that the organisation has accepted and adopted GE technologies. The literature study established that South Africa has adopted GE technologies and has the potential to achieve a 75% adoption rate by 2050 (Bischof-Niemz, Calitz, Mushwana, van Heerden, & Wright, 2019). At the rate at which this firm adopted the GE technologies, the rate of adoption by the existing or old firms might be slower than they need to retrofit the technologies into their old technologies and, therefore, the estimates made in the literature cannot be confirmed from this study.

The advancement of GE innovations will allow the company to transition from using grid power as a base load to fully using GE technologies. The study participants expect that more private energy power producers will emerge because of government's policy relaxation on power production permit requirements and the increased capacity that the IPP has been allowed to exploit. Bischof-Niemz, Calitz, Mushwana, Van Heerden and Wright (2019) revealed it is cheaper for new investments in South Africa to be solar and wind technologies compared to traditional coal-based electricity systems. This finding can only be supported if a new operation can be compared with a previous operation to measure the costs thereof.

6.4.2 Theme #7: Affordability of solar energy

The study participants indicated that consuming solar energy is cheaper than energy from the national grid, as other costs, such as tariffs and other utility services, are not charged with solar power. They added that as solar energy innovations become familiar and more people use; the cost generated also becomes lower.The participants contended that solar energy cost has been reducing slowly over the years as the technologies advance and are at the point where consumers can afford them. Based on this finding, it can be concluded that solar energy costs will drop

further soon because of improved innovations.

The cost of RE was high around the year 2011, and that explained the reason for the low adoption of such technologies by households and organisations (Hascic, Medhi, & Popp, 2011). This literature finding supports the study participant's observation that solar energy will become cheaper than most companies and households adopt it. Dwivedi, Kapoor, and Williams (2014) also support the findings, as they alluded that solar energy is one of the most familiar and attractive methods of combating global warming issues owing to its direct availability. The more consumers use it, the cheaper it gets. The population is expected to increase exponentially in South Africa and other African countries in the next few years; the more the pollution grows, the more the demand for energy (Densing, Kober, Panos, & Schiffer, 2020).

6.4.3 Theme #8: The solar energy supplier capabilities

The capabilities of GE suppliers are a major concern for the organisation. A detailed diligence process, along with an evaluation of the supplier's technical assessment, know-how and experience, was conducted before appointing the solar energy supplier. According to the participants, some suppliers have failed to install solar energy systems owing to a lack of competencies, posing a tremendous risk for customers. The organisation was approached by several suppliers and selected one origination that passed their criteria; however, the company remains open to collaborating with any other supplier capable of producing more GE. Although the solar energy supplier for the organisation demonstrated its organisation's know-how and capabilities using overseas experience, they have not yet commissioned a solar plant in South Africa that remains a risk to the supplying the company. The organisation plans to use grit energy as its base load until there is confidence in the supplier's capability and proven record to supply reliable energy to production plants.

The risk to the organisation for lack of supplier capabilities and competencies has been mitigated by an agreement between the organisation and the supplier providing over-the-fence energy to the production plant. The organisation will use solar power when available and divert it to grid energy if the supplier cannot provide it. This back-up plan minimises the influence of solar power shortage on the plant, whereas the supplier carries the bigger risk. Failure to commission the plant will cost the supplier

considerable money it has invested in procuring the equipment and training personnel.

The supplier indicated that training the technical team for the installation of GE technologies, project management, engineering, and equipment maintenance is critical for the sustainability of the organisation. Skill transfer is one strategy implemented to mitigate the risk of shutting down the business. Knowledge is a key characteristic of GE innovations, and the related skills required to implement the innovation often determine if the innovation gets adopted (Dwivedi, Kapoor, & Williams, 2014). The organisation is determined to use GE only if the suppliers can produce the amount required by their manufacturing plants without interrupting the continuous production processes and, therefore, supplier capabilities play a role in the slow adoption of GE practices.

6.5 Summary of discussion for research question 1 (RQ1)

Both literature and study findings imply that most power generation plants will use power from GE sources as the cost of such technologies has dropped and innovations are becoming more familiar. Hascic, Medhi, and Popp (2011) support the finding as they indicated that the cost of solar energy supply has been dropping since 2022. The cost of storing solar energy, however, is reported to be expensive. According to the study participants, as GE innovations advance and the demand for energy increases, more GE producers and customers will emerge and drive the cost of energy production down. The lower cost of GE will increase adoption thereof.

6.6 Discussion of results for research question 2 (RQ2): What risks are the company exposed to, hindering the complete adoption of green energy practices?

The risks were identified in the literature study as barriers to GE adoption; however, they were not apportioned into details of specific risks affecting GE adoption (Dwivedi, Kapoor, & Williams, 2014). With this study, four key risks that affected the complete adoption of GE practices by the firm were identified. The risks identified were as follows:

- High GE investment costs
- Lack of skills and experience in operating a GE plant
- Lack of financial ability to supply power to a continuous plant
- Frequent upgrades of technology or evolving technological upgrades

The risk of skills shortage, ability to supply power, and frequent technology upgrades directly affect the supplier and the organisation. The supplier can only recover his investment costs and make a profit if the power plant is functional and effective. Although the organisation will be affected should the supplier not be able to produce energy, the cost of such a loss can be minimised by switching to the base load. Here, the lack of power supply will defeat the purpose of using GE technologies.

6.6.1 Theme #9: The green energy technologies are perceived to be expensive

Participants from the study indicated that the cost of acquiring GE storage innovations is high. This finding supports the assertions that the TI are costly and blocks achieving net zero emission targets (Davis, Lewis, Shaner, & al., 2018). Although the supplier has secured funds to produce solar energy and supply the organisation in this study, the supplier cannot afford to acquire infrastructure for solar energy storage. The only way to continuously supplier solar energy to a continuous production plant during the day, night and in adverse weather is through storage of energy when the sun is available.

The shortage of energy storage innovations from the supplier has hindered the organisation's ability to adopt GE technologies. This finding supports the literature findings that continuous energy supply requires storage infrastructure; however, the technologies for storage are expensive (Su, Pang, Tao, Shao, & Umar, 2022). The participants explained that the cost of technology prohibits GE suppliers from maximising the freely available RE sources and, therefore, supplier capabilities concerning financial resources, experience and skills may function as a barrier to GE adoption.

6.6.2 Theme #10: The risks of adopting green energy technologies are higher than the rewards

The first risk is that GE innovations evolve overtime, indicating the organisation would

find it difficult to keep up with the changes as GE production is not their field of expertise. The second risk was that solar energy was unavailable throughout the day, and, therefore, the plant would still forfeit continuous power suppliers from solar energy even after investing money in the infrastructure.

The third risk was that the capital investment required to acquire the GE infrastructure was high. The investment would include purchasing energy storage technologies to ensure a continuous supply of energy if the company's objective was to stay off the grid while operating a continuous process plant. It would have been risky for the company to own such expensive infrastructure without the experience and skills to operate the solar power plant.

These risks led to the organisation outsourcing the GE supply to an external company with sufficient skills and know-how to operate the power plant. The answer to this RQ is that technical know-how, constant changes to GE innovations, and the high cost of investment for the GE infrastructure are the barriers to complete adoption of GE innovations. A shortage of skills and experience in solar energy supply is a risk to the supplier. The supplier focused on building skills through training the technical team and paring of the experienced technical team with juniors to facilitate learning. Shortage of skills to install and maintain the solar energy infrastructure will soon remain a threat; skills take time to develop and diffuse.

What the study has added to the findings from the literature is that constant changes or improvements in GE innovations function as a barrier towards GE adoption as the consumer observes such changes as high risks to the organisation. The capability of suppliers to produce, store and supply power to a continuously operational production plant is a known barrier, as it supports literature by Su, Pang, Tao, Shao, and Umar (2022).

6.7 Summary of discussion for Research Question 2 (RQ2)

The continuous innovation, popularity, accessibility, and availability of GE sources could reduce the cost of technology in the future (Davis, Lewis, Shaner, & al., 2018). The study participants believe that the consolidated effort among countries and advanced innovation of GE storage infrastructure will reduce the cost of technology.

The literature findings around the uncertainty of GE technologies, the high cost of investment and that GE consumers are risk averse by Ahmad, Jabeen, and Zhang (2021) align with the study finding as the organisation mitigated the risk of energy supply failure by outsourcing solar energy from external suppliers.

6.8 Conclusion

The RQs are responded to in this chapter. The research findings for the main RQ indicated the participants are aware of the implications of carbon dioxide emissions to the atmosphere; however, the awareness influenced their observation of GE adoption. Some participants observed that profitability takes more priority than adopting GE technologies, and some believed that government would enforce punitive measures to enforce GE adoption. This finding is supported by literature stating that the function of the government is to enforce regulations and compliance (Li & Taeihagh, 2020). Although other participants believed that government is a prohibitor of GE adoption, it would interest an understanding of the motivation behind the investors' interest towards GE practices and whether the engagements between the local government and the investors emphasising GE adoption.

The participants' attitude towards adopting GE practices was influenced by their experiences in operations that did not use GE. The participants believed that capitalism is a barrier to GE adoption. The company did not invest in the solar plant to reduce technology and human capability challenges. This approach could be observed as a promoter of the slow adoption of GE. Findings from the literature and the study revealed that the slow rate of GE adoption is attributed to the proximity to the innovations (Noseleit, 2018), customers' familiarity with the technologies and lack of experience with the application of GE technologies by the suppliers.

The organisation's strategy to source GE from an independent power producer aims to allow the organisation a focus on its co-competencies, reducing the risk of operating processes they are not competent to run. Although this may sound like risk mitigation, the organisation has effectively been exposed to an additional risk of supply shortage, which it has no control over. To mitigate a shortage of suppliers, the organisation has stayed on the main national grid for back-up. This plan works against the objective of reducing dependency on the grid. To gain control of the

power supplier, the organisation could investigate producing its power; however, the company executive has heightened during the interview that the organisation has no intentions to own a solar production plant.

The participants and literature study indicated that the cost of acquiring GE infrastructure is high and that the major barrier to the production of continuous solar energy production is the lack of storage innovations (Davis, Lewis, Shaner, & al., 2018). According to the participants, the existing innovations require a large land space that the organisation does not have. The cost of purchasing power from GE suppliers was cheaper than the cost of buying energy from the grid. The cost of risks that come with untested technologies has not been identified. Emergency costs and production loss may be far more significant and outweigh the benefits of using solar energy technologies.

The lower cost of consumption will increase the diffusion of GE technologies as most organisations will exploit it to reduce their operational costs. When solar energy becomes more popular, innovation costs will drop as the demand increases. The findings from the literature indicate that the cost of solar energy has been dropping since 2011 (Hascic, Medhi, & Popp, 2011). This finding, however, does not explain why the rate of GE adoption has not drastically increased to indicate that the costs are lower that using energy from the national grid.

It has been discovered from various studies, such as Tobias (2019) and Dwivedy and Kapoor (2014), that the solutions to reducing fossil fuels emissions are through adopting GE technologies, but the diffusion and adoption of such technologies are low. The organisation adopted only 30% of its power consumption from renewable technologies and 20% as recycled energy from its processes. It can be concluded that the rate of GE adoption in this context is low, provided that half of the power used by the organisation is from the national grid and serves as the base load of the production plant.

According to the study findings, the government, the market, and investors have played a significant role in promoting GE adoption, whereas supplier capabilities prohibited the complete adoption of GE technologies. This role of investors might have been observed from a biased lens by some participants who only emphasised

that they had established standards for compliance with GE practices but did not indicate whether they would invest own funds in such technologies. The organisation shifting the responsibility of GE production to the supplier might be a sign that the investors are unwilling to spend their money on such technologies to protect their profits.

The function of investors in this context did not directly promote GE adoption. Provided the state of shortages in the country, some investors may take an interest in the opportunities created by this setback to invest in a power production plant. The interest in the opportunity might be created by returns and not necessarily the need to save the planet. The supplier has secured funds from investors to build the GE production plant with the motivation for those investors.

The main study findings are as follows:

- Government, markets, and investors are the promoters of GE's adoption
- Rapid change and lack of knowledge on technology innovations
- Supplier capability limitations to provide GE is a barrier to GE adoption
- The cost of GE storage is a barrier to the full adoption of GE technologies

GE innovation risks resulted in the slow adoption of the technologies. The contribution to the diffusion of innovation theory is that green energy innovation diffusion depends on the level of risk presented by the innovations and the attitude and perception of end-users. The participants indicated that if GE supply reliability increases, the organisation would increase the uptake of the GE.

CHAPTER 7: CONCLUSION AND RECOMMENDATIONS

7.1 Introduction

The study of promoters and barriers to GE adoption was important to understand why the rate of GE adoption is low in the South African manufacturing industry. The industry contributes the most carbon dioxide emissions into the atmosphere and uses a significant energy compared to other industries in South Africa (Ganda & Milondzo, 2018). Carbon dioxide pollution released into the atmosphere causes global warming, threatening to harm human lives as it causes extreme temperature conditions that human bodies cannot withstand (Bischof-Niemz, Calitz, Mushwana, van Heerden, & Wright, 2019).

The release of carbon dioxide emissions occurs when coal, also known as fossil fuels, is burned and causes an increase in mean ground temperatures. Global warming has become a tropical topic globally. It attracted significant consideration by the world fora, such as the UN. The UN forum merged countries to focus on the adverse effects of global warming while advocating implementing practices that can reduce the carbon dioxide footprint.

The UN aims to reduce or maintain the world's temperature increase to less than 2 degrees over 21 centuries (Li & Taeihagh, 2020). This target can be achieved only if individual countries implement measures to reduce the carbon footprint in the atmosphere and measures to prevent future environmental degradation. It has been discovered from numerous studies, such as Tobias (2019) and Dwivedy and Kapoor (2014), that the solutions to reducing carbon dioxide emissions are through adopting GE technologies; however, the diffusion and adoption of such technologies are low. The study aimed to investigate why the rate of GE adoption by the South African manufacturing industry is low.

7.2 The research context summary

South Africa has been identified as one country that generates significant carbon dioxide emissions globally (Stucki & Woerter, 2016). This is owing to the country's heavy reliance on electricity generated from coal. Coal is a common source of energy and is used globally for the manufacturing of electricity (Stucki & Woerter, 2016).

The study examined the reasons the South African manufacturing industry adopts GE at a low rate by identifying the promoters and barriers of GE technologies. The researcher selected the manufacturing industry for the study as it makes up over 37,7% of energy consumers in the country.

7.3 What we knew

The government has put environmental air policies in place, providing guidelines for air pollution standards to organisations (Li & Taeihagh, 2020). The policies should encourage the public and organisations to implement measures to prevent the release of carbon dioxide emissions into the atmosphere; however, the rate at which measures are implemented is not ideal for curbing the influence of global warming (Tobias, 2019) (Bischof-Niemz, Calitz, Mushwana, van Heerden, & Wright, 2019).

Bischof-Niemz, Calitz, Mushwana, Van Heerden, and Wright (2022) revealed that South Africa has an excellent opportunity to transition from using fossil fuels and achieve up to 75% of the GE share by 2050. This literature research finding demonstrated that South Africa has accepted GE practices and can achieve its target of reducing the carbon footprint in the atmosphere if it considers the opportunities to transition from using coal and adopt GE. The study adds that government policies are crucial instruments to drive and stimulate the diffusion of GE practices (Stucki & Woerter, 2016). The other reason for the slow adoption of GE technologies is that some organisations perceive GE practices as beneficial for the public rather than private and such attitudes have resulted in the slow adoption of GE technologies.

Solar energy was identified as the most common, familiar, and attractive GE innovation attributable to the availability of the sun and has been highly recognised for combating the global warming effects (Dwivedi, Kapoor, & Williams, 2014). The cost of solar energy is reported to be reducing over the years owing to its popularity; however, storage innovations lagged, perceived as expensive (Davis, Lewis, Shaner, & al., 2018). It was known that GE consumers are risk averse and would default to using traditional sources of energy to avoid exposure to risks (Dwivedi, Kapoor, & Williams, 2014).

7.4 What we did not know

Stucki and Woerter (2016) indicate that government policies helped to drive the diffusion of GE technologies; however, policies cause various reactions from companies. The various policies that either promote or prohibit GE adoption were not known. Risks were identified as barriers to GE adoption, but the specific risks that cause the manufacturing industry to adopt green energy practices at a low rate were not identified (Dwivedi, Kapoor, & Williams, 2014). Some characteristics of technology innovation affect the diffusion and adoption of technologies; however, such aspects of innovation have not been identified.

It was also not known whether knowledge and complexity of green energy innovations had made a significant contribution towards the slow adoption of GE technologies (Dwivedi, Kapoor, & Williams, 2014). Allen, et al., (2017) empirical investigations of factors that may act as promoters or barriers to adopting GE technologies to uncover the reasons for the slow adoption of technologies within the manufacturing industry.

7.5 The research questions

The study was conducted to investigate the promoters and barriers of GE adoption, as recommended by Allen et al. (2017). Divergences guided the formulation of the RQs in the literature. The primary RQ was developed based on recommendations by Allen et al. (2017). Three RQs needed to be answered. The primary question is:

What are the green energy adoption's promotors and barriers?

The research sub-questions are:

RQ1: What motivated the company to consider green energy technologies?

RQ2: What risks are the company exposed to, hindering the complete adoption of green energy practices?

7.6 How the questions were answered

A case study research design was selected where the researcher used an exploratory approach to collect data to develop the body of knowledge on the GE phenomena. The research focused on adopting GE practices by a South African manufacturing company.

Data was collected through face-to-face and online semi-structured interviews. The rationale behind the research method choice was to allow the researcher to collect insights about the actors that promote or prohibit adopting GE practices. According to Bonaiut et al. (2016), the mono-qualitative research methodology attempts to answer questions such as *"how?", "what?" and "why"?.* The research approach considered the participants' perceptions, experiences, reactions, beliefs, and emotions. The data were collected using a cross-sectional approach, where multiple participants were interviewed at a single point, as recommended by Saunders and Lewis (2018).

An inductive listening approach was used, collecting in-depth knowledge of the GE phenomena to build on the existing theory using patterns and occurrences to formulate the research propositions. The organisation was a unit of analysis for the study, whereas the level of analysis was up to the individuals with manufacturing industry experience.

Ten (10) participants were interviewed and recorded on teams. Saturation was achieved after interviewing Participant 9. The audio recordings were then transcribed and analysed using Atlas.ti. After analysing the participants' data, the researcher decided to re-interview Participants 7 and 9, attributable to their level of involvement in the production plants. Data was prepared for analysis by coding each research interview transcript and drawing the study themes.

7.7 Research findings summary

The codes that emerged from the participant's data were summarised into themes. The themes were grouped and mapped with the RQs for analysis and responses to the RQs. The findings analysed under each theme were interpreted against the literature study findings. The findings are as follows;

7.7.1 The primary research question: *What are the green energy adoption's promotors and barriers?*

Under the theme "contextualising green energy", the study aimed to establish how the contextual understanding of GE by the participants affected their attitude towards GE adoption. The participants understood GE within the manufacturing context in two ways. The first group (7/10) described GE as energy produced from renewable sources, whereas the second group (3/10) described it as energy produced without emitting carbon dioxide into the atmosphere but not necessarily produced from renewable sources. Su, Pang, Tao, Shao, and Umar (2022) contend there is no single way to achieve net zero carbon dioxide emissions, and that promoting other TI, such as capturing carbon dioxide through the recycling processes, will curb the release of carbon dioxide emissions to the atmosphere. This literature finding aligns with the observation of the second minor group.

Other factors identified by the study participants as barriers to GE adoption are rapid changes and lack of knowledge on technology innovations. The organisation outsourced GE's production services to avoid the risk of derailment from its co-competencies. It was concluded that how the first group (7/10) defined GE did not affect how they observed business priorities and that they felt that being productive was a key performance indicator compared to implementing GE technologies.

Most are external service providers and are not permanent employees of the company. The company executive and project manager's observation were that adoptions of GE takes priority as it is one objective to mitigate carbon footprint, and key stakeholders, such as the government, the markets, and investors, are advocates for a green environment. Matsuo, Steinemann, Schmidt, and Steffen (2018) contributed to the finding by adding that local policies need to support the drivers of GE, such as international markets and investors.

Research Question 1 (RQ1): *What motivated the company to consider green energy technologies?*

The advantage that a new organisation has is the opportunity to choose the most recent and advanced technologies that exist in the market. The cost of GE

technologies has reduced over time as they become more popular and allow organisations to adopt the innovations. According to the participants, the affordability of GE technologies played a motivating role for the company to adopt GE technologies. Bischof-Niemz, Calitz, Mushwana, Van Heerden and Wright (2019) revealed that it is cheaper for new investments in South Africa in solar and wind technologies compared to the traditional coal-based electricity systems. This finding was supported by the study's outcomes, where the organisation opted to buy solar energy over-the-fence from a supplier to reduce its operational costs of owning the technology. Installing the GE plant would require significant investment and skills to operate the plant. The supplier's risk of failure and cost motivated the organisation to adopt GE innovations.

The adoption of RE and circular economic systems by the organisation is one of the critical strategic means to ensure the long-term sustainability of the organisation and to attract investors and government support. Although the initial solar energy supply to the plant is only 30% of the total load required, the company executives have committed to using up to 100% of solar energy in their manufacturing plant. The supplier also motivated the organisation by investing in energy production plants and demonstrating its technical capabilities through successful international operation. Although the capabilities were not assessed locally, the organisation carries no risk as it did not invest in infrastructure and skills.

7.7.2 Research Question 2 (RQ2): *What risks are the company exposed to, hindering the complete adoption of green energy practices?*

Four key risks were identified as barriers to GE adoption by the organisation's study participants. The organisation's manufacturing plant operates continuously, without interruptions. The adoption of innovations, such as solar energy, poses a risk of a shortage of power supply on days when the sun is not shining. Su, Pang, Tao, Shao, and Umar (2022) suggest that the only way to supply energy to a continuous plant continuously is through storing the energy when the sun is available.

The literature study further adds that GE storage innovations are expensive and prohibits adopting GE technologies (Su, Pang, Tao, Shao, & Umar, 2022). The organisation could adopt only 30% of solar energy and will continue to use GE as

the base load to mitigate for a shortage of solar energy supply. The reason for the organisation's decision to keep their base load as grid power is that the risks of shutting down the plant owing to a shortage of power supply are greater than the risks of adopting GE, according to the participants.

7.8 Contributions to scholarly debate

The main divergence in the diffusion of innovation theory is around drivers of GE adoption, that led to the slow diffusion of GE technologies. The findings from the study have aligned with the literature around the idea that TI' characteristics slow down the rate of technology diffusion and adoption. The GE innovations in South Africa cannot provide continuous power supply to customers (Su, Pang, Tao, Shao, & Umar, 2022). The innovation of technologies for the storage of GE affects the rate at which the technologies are adopted. In this context, the innovation of continuous power supply is a barrier to GE adoption, as emphasised by the participants.

The literature study has suggested that RE technologies curb the release of carbon dioxide and, therefore, are the energy recycling methods (Dwivedi, Kapoor, & Williams, 2014) and (Su, Pang, Tao, Shao, & Umar, 2022) consecutively. The popularity of RE technologies narrowed the GE definition and implied there would be a net zero carbon dioxide in the atmosphere when using such technologies. It is misleading to say that renewable technologies are free from carbon dioxide. If GE implied that the sources of the technology are not made from natural resources, then TI will seize to exist because all materials consumed by humans form part of an ecosystem.

The role of the government in GE adoption has been identified as a critical driver of GE adoption (Stucki & Woerter, 2016). The study participants contended that there are features of government policies that create barriers to GE adoption. The recent policy developments in giving IPP more rights or permission to produce more power do not signify that the complete role of government promotes GE adoption.

The study established that the function of investors promotes GE innovations; however, some participants felt investors pressured organisations to increase productivity to maximise their returns. Investors weigh the risks and support

initiatives when forced to comply with regulations.

The key contribution to the innovation of diffusion theory is that the rate of GE adoption may increase when the risk of supply shortage reduces. The assumption is made on the bases that consumers' attitudes and perceptions of GE are positive, and that additional risks, such as incompetency and a lack of experience of suppliers have been mitigated.

7.9 Suggestions for future research

Future research should focus on establishing an effective way between the energy recycling technologies and the RE technologies to reduce carbon footprint. The two methodologies are not mutually exclusive, and one technology has not been proven to be more effective than the other. The findings from such an investigation may assist the manufacturing industry in adopting energy models suitable to their specific applications and to speed up the rate of GE adoption.

Provided the power supply crisis in South Africa, there is no single energy source that does not carry some level of risk at the moment. To make it practical for manufacturing companies to adopt GE, various energy models should be studied to aid organisations in selecting what is suitable for their operations. The model will provide manufacturing firms with energy supply reliability, security, and flexibility to switch between different sources as and when needed. The firms could also use the opportunity to utilize energy from a cost-effective source and design strategies to exploit cheaper sources.

To assist organisations with trialled and tested innovations, the government and private sector need to collaborate and establish platforms to innovate local GE technologies. The platform should also develop skills for GE and circular economic applications. Small firms may also use such platforms to identify the entrepreneurial opportunities available within the industry. The study was conducted based on a single firm context, and the operations are still new. It would be interesting to establish the drivers of GE adoption within traditional manufacturing firms that still rely heavily on coal. The role of government in GE adoption also needs to be explored in the existing manufacturing plant.

Government and private sector relationships may affect the rate at which GE technologies are adopted. The study findings emphasised that the government played a significant role in promoting GE adoption; however, there were no details shared to indicate the relationship between the government and the firm. The investor's role in promoting GE practices needs further investigation, as the findings from the study participants were contradicting.

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APPENDIX 1: INTERVIEW GUIDE

Interview guide

Name: _____ Job Title: _____

Organisation: _____ Job Title: _____

Gender: _____ Age: _____

Race: _____

Interview Start Time: _____

Interview end Time: _____

Thank you for affording me an opportunity to interview you for my research project. Your inputs and time are highly valuable and appreciated. I would like to first give you a background of my study before we start with the interview.

The green environment has induced great motivation for global leaders to seek ways to keep the environments free of emissions. Global warming, which is caused by air pollution has become a major threat to public health and humanity. The topic of climate change has been prioritised throughout the world and as such governments have made targets to reduce carbon-dioxide emissions to atmosphere.

South Africa, just like many other countries has committed to reduce its carbon dioxide footprints in the atmosphere through adoption of practices that minimize air pollution. The common practices that are available include usage of solar energy amongst other green energy technologies. It has to be noted however, that the rate at which green energy practices are adopted in South Africa and most parts of the world is very slow.

Academic studies have been conducted to explore various green energy technologies and implementation thereof, however it remains unknown as to why some countries like South Africa are still highly dependent on energy that is generated from fossil fuels.

This brings us to the topic of today. Before we start, may I kindly ask that you fill in the consent form, to indicate that you are comfortable to be interviewed on this topic? I would also like to ask for your permission to record the interview and take notes during the interview?

Understanding the barriers and promotors of green energy adoption within the firm

The research focuses mainly on the diffusion of green energy innovation within the manufacturing industry in South Africa. A case study approach was taken, where the researcher chose to use a single firm to study the diffusion of innovation phenomena.

The diffusion of innovation entails how new ideas are spread across the organization and the adoption of such new ideas. The adoption concept deals with the acceptance of the technologies by the organization. The researcher is interested in understanding the factors that led to adoption of green energy by the organization.

Main Research Question

Interview Question 1

What are the promoters or barriers of green energy adoption?

Potential prompt: Technological knowledge or experience, financial resources, behavioural factors

---

Research Question 1

Interview Question 2

What do you believe has motivated the company to consider green energy technologies?

Potential prompt: legislation, financial benefits, community benefits

---

Research Question 2

Interview Question 3

What risks is the company exposed to, which hinder the complete adoption of green energy?

Potential prompt: technological knowledge or experience, financial risks, safety risks

---

Suitability of participant

Interview Question 4

Could you describe some of the successful or failures of green energy technology adoption that you have experienced or witnessed?

Potential prompt: Successful or failure of solar power installation, technology efficiencies or inefficiencies

---

Interview Question 5

What are some of the green energy technologies that you are aware of?

Potential prompt: Solar power, wind power, Biomass, Hydropower

---

APPENDIX 2: REVISED INTERVIEW GUIDE

Interview guide

Name: _____ Job Title: _____

Organisation: _____ Job Title: _____

Gender: _____ Age: _____

Race: _____

Interview Start Time: _____

Interview end Time: _____

Thank you for affording me an opportunity to interview you for my research project. Your inputs and time are highly valuable and appreciated. I would like to first give you a background of my study before we start with the interview.

The green environment has induced great motivation for global leaders to seek ways to keep the environments free of emissions. Global warming, which is caused by air pollution has become a major threat to public health and humanity. The topic of climate change has been prioritised throughout the world and as such governments have made targets to reduce carbon-dioxide emissions to atmosphere.

South Africa, just like many other countries has committed to reduce its carbon dioxide footprints in the atmosphere through adoption of practices that minimize air pollution. The common practices that are available include usage of solar energy amongst other green energy technologies. It has to be noted however, that the rate at which green energy practices are adopted in South Africa and most parts of the world is very slow.

Academic studies have been conducted to explore various green energy technologies and implementation thereof, however it remains unknown as to why some countries like South Africa are still highly dependent on energy that is generated from fossil fuels.

This brings us to the topic of today. Before we start, may I kindly ask that you fill in the consent form, to indicate that you are comfortable to be interviewed on this topic? I would also like to ask for your permission to record the interview and take notes during the interview?

Understanding the barriers and promotors of green energy adoption within the firm

The research focuses mainly on the diffusion of green energy innovation within the manufacturing industry in South Africa. A case study approach was taken, where the researcher chose to use a single firm to study the diffusion of innovation phenomena.

The diffusion of innovation entails how new ideas are spread across the organization and the adoption of such new ideas. The adoption concept deals with the acceptance of the technologies by the organization. The researcher is interested in understanding the factors that led to adoption of green energy by the organization.

Main Research Question

Interview Question 1

What is your understanding of green energy?

Interview Question 2

What are the promoters or barriers of green energy adoption?

Potential prompt: Technological knowledge or experience, financial resources, behavioural factors

Research Question 1

Interview Question 3

What do you believe has motivated the company to consider green energy technologies?

Potential prompt: legislation, financial benefits, community benefits

---

Research Question 2

Interview Question 4

What risks is the company exposed to, which hinder the complete adoption of green energy?

Potential prompt: technological knowledge or experience, financial risks, safety risks

---

Suitability of participant

Interview Question 5

Could you describe some of the successful or failures of green energy technology adoption that you have experienced or witnessed?

Potential prompt: Successful or failure of solar power installation, technology efficiencies or inefficiencies

---

Interview Question 6

What are some of the green energy technologies that you are aware of?

Potential prompt: Solar power, wind power, Biomass, Hydropower

---

APPENDIX 3: INTERVIEW CONSENT FORM

Interview Consent Form

I am a student at the university of Pretoria's Gordon Institute of Business Science (GIBS) and completing my research in partial fulfilment of the requirements for the degree of Masters of Business Administration (MBA).

I am currently conducting a research to explore the barriers and promotors of green energy adoption within a South African manufacturing company. The purpose of this interview is to acquire insights from your personal experience relating to the topic. The interview will help the researcher to understand how the green energy practices were diffused within the organization and adopted as a means to mitigate the effects of global warming. The interview will last for about forty-five minutes to an hour.

Please note that your participation is voluntary and that you are allowed to withdraw should you not feel comfortable to proceed with the interview. There will not be penalties for withdrawal, and data will be reported without identifiers to maintain confidentiality.

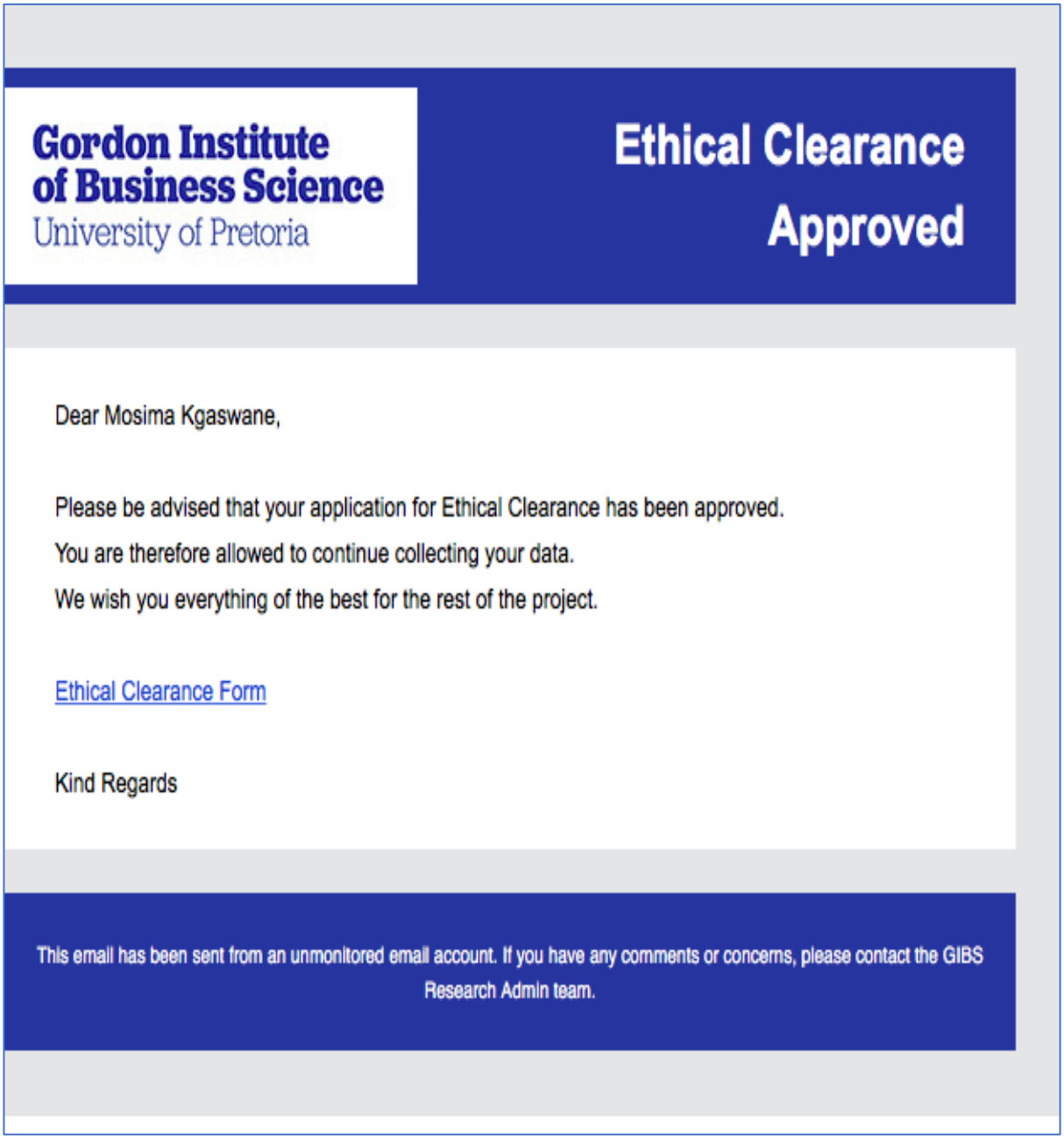
If you have any concerns, please feel free to communicate with me or my supervisor on the below details;

Researcher's Name	Mosima Kgaswane	Supervisor's Name	Johan Olivier
Email	28509545@mygibs.co.za	Email	olivierjo@gibs.co.za
Cell Phone	082 638 8237	Cell Phone	083 452 5539

Signature of Participant: _____ Date: _____

Signature of Researcher: _____ Date: _____

APPENDIX 4: ETHICAL CLEARANCE APPROVAL



Gordon Institute of Business Science
University of Pretoria

Ethical Clearance Approved

Dear Mosima Kgaswane,

Please be advised that your application for Ethical Clearance has been approved.

You are therefore allowed to continue collecting your data.

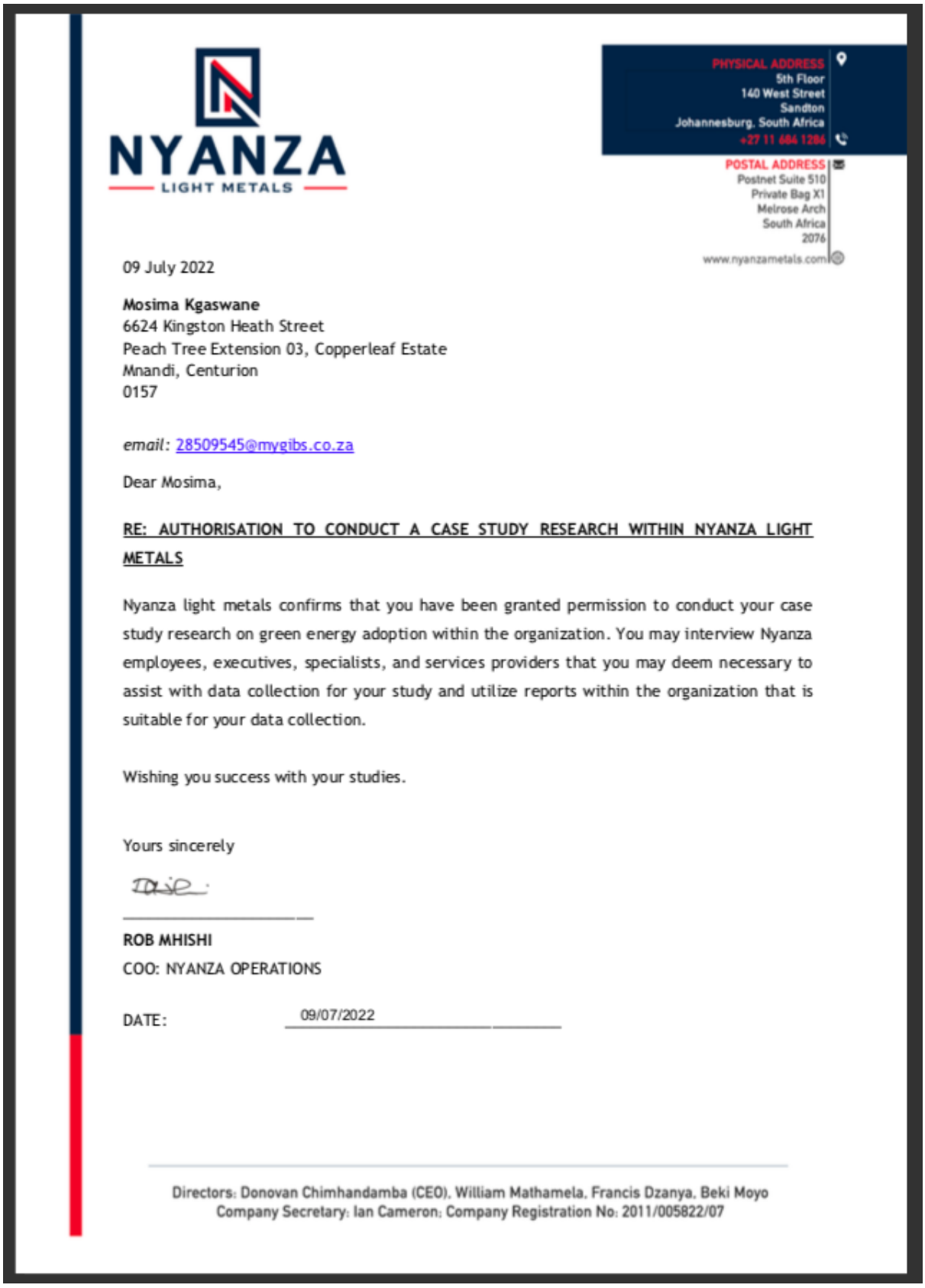
We wish you everything of the best for the rest of the project.

Ethical Clearance Form

Kind Regards

This email has been sent from an unmonitored email account. If you have any comments or concerns, please contact the GIBS Research Admin team.

APPENDIX 5: CONSENT LETTER FROM THE COMPANY



NYANZA
LIGHT METALS

PHYSICAL ADDRESS
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140 West Street
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Johannesburg, South Africa
+27 11 684 1286

POSTAL ADDRESS
Postnet Suite 510
Private Bag X1
Melrose Arch
South Africa
2076

www.nyanzametals.com

09 July 2022

Mosima Kgaswane
6624 Kingston Heath Street
Peach Tree Extension 03, Copperleaf Estate
Mnandi, Centurion
0157

email: 28509545@mygibs.co.za

Dear Mosima,

RE: AUTHORISATION TO CONDUCT A CASE STUDY RESEARCH WITHIN NYANZA LIGHT METALS

Nyanza light metals confirms that you have been granted permission to conduct your case study research on green energy adoption within the organization. You may interview Nyanza employees, executives, specialists, and services providers that you may deem necessary to assist with data collection for your study and utilize reports within the organization that is suitable for your data collection.

Wishing you success with your studies.

Yours sincerely

ROB MHISHI
COO: NYANZA OPERATIONS

DATE: 09/07/2022

APPENDIX 6: LIST OF CODES

Number of codes	Code Description	Quotations	Groups
1	Advantages of green field projects	8	Green Energy Innovation
2	Affordable technology	9	Green Energy Adoption
3	Alternative energy saving plan	2	Green Energy Adoption
4	Alternative energy sources	2	Green Energy Innovation
5	Availability of the sun	12	Green Energy Innovation
6	Bad weather conditions	5	Green Energy Innovation
7	Capitalism	10	Green Energy Adoption
	Capital Investment	7	Green Energy Adoption
8	Circular economy	3	Green Energy Innovation
9	Collaboration	2	Green Energy Diffusion

10	Competition	1	Green Energy Adoption
11	Cost saving	16	Green Energy Adoption
	Cost management	6	Green Energy Adoption
12	Effects of load shedding	8	Green Energy Adoption
13	Efficiency	4	Green Energy Adoption
14	Emissions	10	Green Energy Adoption
15	Energy supply variability	4	Green Energy Adoption
16	Equipment reliability	4	Green Energy Adoption
17	Expensive	31	Green Energy Adoption
18	Experience on solar energy equipment	11	Green Energy Innovation
19	Government influence	1	Green Energy Diffusion
20	Green energy adoption is costly	4	Green Energy Adoption
21	Green energy adoption plan	9	Green Energy Adoption

22	Green energy definition	19	Green Energy Innovation
23	Green energy installation successes	9	Green Energy Adoption
24	Green energy suppliers & options	15	Green Energy Innovation
25	High priority	2	Green Energy Adoption
26	High maintenance costs	5	Green Energy Adoption
27	Hybrid energy supply model	4	Green Energy Adoption
28	Incentives	4	Green Energy Diffusion
29	Investors	20	Green Energy Diffusion
30	Knowledge of green energy technologies	15	Green Energy Innovation
31	Lack of compliance to the legislation	9	Green Energy Adoption
32	Lack of funds	2	Green Energy Adoption
33	Lack of technology	3	Green Energy Innovation

	knowledge		
34	Lack of leadership	7	Green Energy Diffusion
35	Legislation to enforce green energy	14	Green Energy Diffusion
36	Limitations of solar	18	Green Energy Innovation
37	Long term	22	Green Energy Adoption
38	Low green energy adoption	4	Green Energy Adoption
39	Low priority	5	Green Energy Diffusion
40	Lower cost of production	8	Green Energy Adoption
41	Motivation to adopt green energy	9	Green Energy Adoption
42	Negative attitude	11	Green Energy Diffusion
43	Network constraint	3	Green Energy Innovation
44	Permit requirements	2	Green Energy Diffusion
45	Positive behaviour	20	Green Energy Diffusion

46	Preferred energy source	24	Green Energy Diffusion
47	Productivity	8	Green Energy Adoption
48	Promoters of green energy	44	Green Energy Diffusion
49	Recommended percentage of adoption	5	Green Energy Diffusion
50	Regulation promotes green energy adoption	11	Green Energy Diffusion
51	Reliability of electricity supply	16	Green Energy Adoption
52	Require support	45	Green Energy Diffusion
53	Return	7	Green Energy Diffusion
54	Risk mitigation	19	Green Energy Adoption
55	Risks	44	Green Energy Adoption
56	Solar energy infrastructure investment	6	Green Energy Adoption

57	Space for solar energy	6	Green Energy Innovation
58	Successful installation of green energy technologies	8	Green Energy Innovation
59	Sustainability	32	Green Energy Innovation
60	Technical constraints	6	Green Energy Innovation
61	Technology	32	Green Energy Innovation
62	Technology not proven	6	Green Energy Innovation
63	The company driving energy adoption	2	Green Energy Adoption
64	Unavailability of energy storage	10	Green Energy Innovation
65	Zero Co2 emission is not possible	7	Green Energy Adoption
66	The market promotes green products	10	Green Energy Diffusion

APPENDIX 7: MERGED CODES

Code	Quotations	Groups
Advantages of green field projects	23	Green Energy Innovation
Affordable technology	32	Green Energy Adoption, Green Energy Diffusion
Alternative energy saving plan	2	Green Energy Adoption
Alternative energy sources	2	Green Energy Innovation
Bad weather conditions	5	Green Energy Innovation
Capitalism	24	Green Energy Adoption, Green Energy Diffusion
Efficiency	18	Green Energy Adoption
Expensive	36	Green Energy Adoption
Green energy definition	19	Green Energy Innovation
Green energy installation successes	14	Green Energy Adoption
Green energy suppliers &	28	Green Energy Adoption, Green Energy Diffusion,

Code	Quotations	Groups
options		Green Energy Innovation
Investors	20	Green Energy Diffusion
Legislation to enforce green energy	28	Green Energy Diffusion
Motivation to adopt green energy	11	Green Energy Adoption
Negative attitude	17	Green Energy Diffusion
Positive behaviour	20	Green Energy Diffusion
Preferred energy source	24	Green Energy Diffusion, Green Energy Innovation
Promoters of green energy	44	Green Energy Diffusion
Regulation promotes green energy adoption	11	Green Energy Diffusion
Require support	47	Green Energy Diffusion
Risk mitigation	19	Green Energy Adoption
Risks	138	Green Energy Adoption, Green Energy Diffusion,

Code	Quotations	Groups
		Green Energy Innovation
Sustainability	32	Green Energy Innovation
Technology	49	Green Energy Innovation
The market promotes green products	10	Green Energy Diffusion

APPENDIX 8: EDITING CERTIFICATE

Nr: 202679

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LANGUAGE EDITING CERTIFICATE

Report title:	Barriers and promotors of green energy adoption within a South African manufacturing company
Author/s:	Mosima Kgaswane
Institution:	Gordon Institute of Business Science
Date Issued:	25 October 2022

This document certifies that the manuscript listed above was edited for proper English language, grammar, punctuation, spelling, and overall style. Neither the research content nor the author's intentions were altered in any way during the editing process. Documents receiving this certification should be English ready for publication; however, the author has the ability and choice to accept or reject our suggestions and changes.

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Warm regards

Elizabeth Marx

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